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WORTHIES OF SCIENCE.

WORTHIES OF SCIENCE.

BY

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AB. D (2)

"They (the Universities) began, as is well known, with their grand aim directed on Theology, their eye turned earnestly on Heaven. And perhaps, in a sense, it may be still said, the very highest interests of man are virtually intrusted to them. In regard to Theology, as you are aware, it has been the study of the deepest heads that have come into the world,—what is the nature of this stupendous universe, and what are our relations to it, and to all things knowable by man, or known only to the great Author of man and it."

THOMAS CARLYLE, *Inaugural Address at Edinburgh*, 1866.

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PREFATORY NOTE.

WE often meet with those who believe either that science creates a prejudice against religion, or that religion produces a prejudice against science. Many suppose that they are incompatible. The object of this volume is not to reason on the subject, but to show that, in a large number of instances, scientific men have illustrated in their lives a perfect harmony between the two pursuits.

Complete biographies must not be looked for on these pages. Only such points are introduced as serve to present clearly to every reader the kind of union just noticed. Each "worthy" is left to speak on both scientific and religious matters, as much as is convenient, in his own language; or summaries of his discoveries and opinions are drawn from sources acknowledged to be trustworthy.

Thanks are due to Dr. Risdon Bennett, F.R.S., President of the Royal College of Physicians; Mr. Dunkin, of the Royal Observatory, Greenwich; and S. Rowles Pattison, Esq., F.G.S., for valuable assistance in revising those parts of the book which relate to discoveries made by the illustrious men described. Some valuable paragraphs and suggestions by the last of these gentlemen have been gratefully adopted in the sketch of Professor Sedgwick.

CONTENTS.

PAGE

Roger Bacon . . 1214–1292 1

Nicholas Copernicus. 1472–1543 26

Francis Bacon . . 1561–1626 45

René Descartes . 1596–1650 67

Blaise Pascal . . 1623–1662 84

Isaac Barrow . . 1630 (?)–1677 111

Robert Boyle . . 1626–1691 130

John Locke . . 1632–1704 151

John Ray . . . 1628–1705 175

Gottfried W. Leibnitz 1646–1716 193

Isaac Newton . . 1642–1727 209

Georges Cuvier . 1769–1832 234

John Dalton . . 1766–1844 249

Michael Faraday . 1791–1867 260

David Brewster . 1781–1869 281

John F. W. Herschel 1792–1871 300

Adam Sedgwick . . 1787–1873 314

WORTHIES OF SCIENCE.

Roger Bacon.

1214–1292.

In the city of Oxford, so classical and so mediæval, there exists a bridge which once spanned the river with forty stone arches; they are now reduced to three, and were rebuilt fifty years ago. The Abbots of Abingdon held their court on this spot, in a building long since swept away; there, also, rose a gateway, over which was a chamber, containing MSS. written in strange characters, also many mysterious instruments and preparations, such as excited the wonder of all observers. Within those walls lived and studied Roger Bacon, who, born about 1214, died in 1292. At night he is said to have ascended the tower stairs, and from the top to have gazed on the stars, and watched the phases of Jupiter and Venus, as they shone over the meadows on the banks of the Isis; by day he is said to have busied himself with retorts and the melting of metals, or, with a rare curiosity, to have sought after the mysteries of nature in studies and experiments connected with the infantine science of chemistry. Scarcely anybody could understand him. Odd stories were told of what he was after; and not a few people imagined that he must be holding intercourse with spirits of the air, or with black prisoners of the lower world.

Oxford then was very different from what Oxford is now. No such pile of buildings existed then as the College of Christ Church, with its tower and bells not far from the bridge. Nor did the tower of Magdalen at that period throw its shadow over the river; nor was the present St. Mary's in being. Charming old cloisters we now see enclosing bright green lawns, suggesting poetic dreams, had not then been built; and the stately edifices of quaint architecture adorning the High Street were among things to come. But Oxford was already a renowned seat of learning, and men came there from all quarters to teach or to study. There were schools established in humble buildings very unlike the colleges of our day. They were ventures of enterprising scholars, who sought a livelihood, or were desirous of diffusing knowledge, rather than grand foundations endowed by kings and queens and nobles.

Two orders of friars, the Dominicans and the Franciscans, who made their appearance in the beginning of the thirteenth century, were amongst the most erudite and active teachers of their age; and the latter of these orders took a leading part in the work of tuition in the midland university. Roger Bacon was a Franciscan friar, and might be seen walking Oxford streets,—then consisting of low-roofed tenements and little open shops, which straggled about regardless of order. This member of a distinguished brotherhood would be dressed in the usual characteristic habit—a long grey coat down to the heels, a girdle of cord round the waist, and an outer cloak thrown over the shoulders, to which was attached an ample cowl.

Roger was a devout member of the fraternity, and a profound theologian. Theology was then regarded as queen of the sciences. All knowledge came into connection with it. Whatever the circumference of study, it had lines reaching from every point to the essential subject of inquiry and interest,—the relation of God to man, of man to God. Religion gave an inspiration to all the thinkers of the day; it set them on paths of inquiry; it threw a hallowing light over objects of research. Nothing is more obvious in the writings of Roger Bacon than his constant reference to theology in one way or other. Scripture history, Scripture doctrine, Scripture expressions, Scripture references, abound on his pages. Evidently his mind was imbued with religious thoughtfulness, and it led him sometimes to insist upon sacred associations with intellectual philosophy such as startle a modern reader.

I. It is necessary at once to pay some attention to Roger Bacon's religious views, before proceeding to notice his philosophical opinions. Any one who has only heard of him as a scientific teacher might expect to find in his writings little else than disquisitions on matters relating to science; but he will be surprised, on looking into his books, to discover how many theological references and allusions appear from beginning to end. His reverence for the Scriptures was profound. He uses the strongest expressions respecting the Bible as a depository and standard of truth, saying with Augustine, that what is true may there be found, and what is contrary to truth is there condemned. He quotes Ambrose, to the effect that in Christ are all the treasures of wisdom and knowledge, that he who knows Him needs to seek nothing more, for He is perfect virtue and perfect wisdom. What is sought elsewhere, Bacon remarks, will here be found; and as sacred Scripture affords this knowledge, it is clear that it includes all truth, and that what is contrary to it is error, and can have nothing but the name of wisdom. He has much to say on the subject of Scripture in connection with human knowledge; and amidst allegorical interpretations and theological positions characteristic of the age, he contends for the close connection between religion and science.[1] He looked upon Divine revelation as the most precious source of human knowledge, without which, all that man can discover would fail to serve the highest purpose of his existence.

In Bacon's musings on revelation and nature, and on faith and reason, he went so far as almost, if not quite, to touch the renowned argument of Bishop Butler on the analogy between natural and revealed religion. He saw difficulties in the one, and difficulties in the other; in short, things incomprehensible by reason in both these worlds of human thought. "To him," he acutely remarks, "who denies the truth of the faith because he is unable to understand it, I will oppose, in reply, the course of nature as we have seen it in examples."[2] Here we have the pith of the Analogy. A sentence in Origen is drawn out into a treatise by the profound and patient reasonings of the English bishop; also a condensation of the same method is found in the writings of the English friar. "These, and the like," Bacon goes on to say, "ought to move men, and to prompt them to the reception of Divine truths. For if in the lowest objects of creation truths are found before which the inward pride of man must bow and believe, though it cannot understand, how much more should man humble his mind before the glorious truths of God!"[1]

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[1] Part II., chaps. 3 and 8. Jebb's edition of *Opus Majus*, pp. 24, 40.

[2] *Opus Majus*, p. 476.

Bacon has been regarded as a reformer before the Reformation; but it must not be supposed that he openly denied any dogmas of the Church, as did John Wycliffe and Martin Luther. It would be difficult, perhaps, to find a passage in the writings of this remarkable man plainly contradicting mediæval theology; but numerous instances can be cited indicative of views which tended to undermine the ecclesiastical system of the age. He says that saints, as well as philosophers, have fallen into error, that Augustine and Jerome had to retract at one time what they held at another, and that Paul resisted Peter because he was to blamed:[2] these statements are put forth, not in a cautious and guarded manner, but so as to appear very offensive to many Romish theologians.[2] He nowhere repudiates Church authority, indeed he speaks of it as proceeding from God; but he opposes "false and arrogant authority, springing from thirst of power, and the ignorance of the multitude." Of the fathers, as of philosophers, he says, "They have not only permitted us and advised us to change what is humanly imperfect, but have set the example of doing so with their own teachings. Had they lived until now, they would have improved and changed much more." [1]

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[1] *Opus Majus*, p. 476. [2] *Ibid.*, p. 10.

Bacon's intimacy with Robert Grossetête, Bishop of Lincoln, has been often noticed. The fact, however, is disputed by some; but it is difficult to understand how the belief of such a friendship could have got abroad as it did, if there had been no foundation for it; besides, there seems nothing improbable in the fellowship of two such inquisitive minds, two such independent persons, and of the renowned bishop he speaks with profound respect.[2] Grossetête was, indeed, more practical than speculative, more of a churchman than a theologian or a philosopher; but he took the patriotic, and what may be called the liberal side in the ecclesiastical politics of his day, and resisted decidedly the encroachments of the papal see upon the rights and privileges of the English Church. Though Bacon, as a Franciscan, and therefore by the rules of his order an obedient servant of the pope, was pledged to the maintenance of Romish claims, yet it is quite possible, looking at the independence of his mind and character, that he had sympathies with such a man as Grossetête in his opinions on contemporary ecclesiastical questions. The schoolmen showed wonderful ingenuity in reconciling what might appear to us glaring inconsistencies; and one would not wonder to find Friar Roger agreeing with Bishop Robert, and at the same time contending that his views were in perfect harmony with the obligations of his order; just as, no doubt, he had a way of reconciling what he said about the saints, the fathers, and the Apostle Peter, with a perfectly orthodox submission to the authority of the Church and the Bishop of Rome.

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[1] Herzog, *Cyclop.*, art. "Bacon."

[2] Robertson's *Church Hist.* (Edit. 1374), vol. vi. p. 476. He cites as authority Bacon's minor works.

II. We must now proceed to notice Roger Bacon's teachings in relation to philosophy. The state of opinion in Oxford in reference to philosophy must be considered before we can carefully appreciate what was accomplished by Bacon. The authority of Aristotle was unacknowledged by the Church in earlier ages. He was condemned as an apostle of reason, and as in bondage to the impressions of sense. So late as the twelfth century there occurred a violent outburst against his works; the latter were collected and burnt, and his readers were reviled and excommunicated. After this the tide turned. Many saw that injustice had been done to the productions of a great thinker; and here it is to be observed that Aristotle was not, in some branches of physical science, by any means so far removed as some imagine from modern methods of observing facts. "From his work on animals, which has descended to us," says Sir J. F. W. Herschel, "we are enabled to appreciate his powers of observation; and a parallel, drawn by an eminent Oxford professor, between his classifications and those of the most illustrious of living naturalists, shows him to have attained a view of animated nature in a remarkable degree comprehensive, and which contrasts strikingly with the confusion, vagueness, and assumption of his physical opinions and dogmas."[1]

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[1] *Discourse on the Study of Natural Philosophy*, p. 109.

In the thirteenth century, Aristotle was as much extolled as he had been before abused — as much studied as he had been before forgotten. Bacon noticed the revolution. "Aristotle is now called peculiarly the philosopher; yet there was a time when his philosophy was silent and unregarded, either on account of the rarity of copies of his works, or their difficulty; or from envy, till after the time of Mahomet, when Avicenna and Averroes, and others, recalled this philosophy into the full light of exposition. And although the *Logic* and some other works were translated by Boethius from the Greek, yet the philosophy of Aristotle first received a quick increase amongst the Latins at the time of Michael Scot, who in the year of our Lord 1230 appeared, bringing with him portions of the books of Aristotle on natural philosophy and mathematics. And yet a small part only of the works of this author is translated, and a still smaller part is in the hands of common students."[1] In another place Bacon condemns the translations of Aristotle as badly executed. "If I had power over them I would have them all burnt; for it is only a loss of time to study them, and they are a cause of error and a multiplication of ignorance beyond expression." "The common herd of students, with their heads, have no principle by which they can be excited to any worthy employment: and hence they mope, and make asses of themselves over their bad translations, and lose their time and trouble and money."[2] He exposed the errors contained in Latin versions of Aristotle derived from the Arabic, and wisely insisted upon the importance of studying authors in their original language.[1]

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[1] *Autonomaticæ*, quoted by Whewell, *Hist. of Inductive Sciences*, i. p. 370. Whewell gives an interesting sketch of Roger Bacon's philosophy both in his *Philosophy* and *History of the Inductive Sciences*.

[2] Quoted by Whewell, *Hist. Ind. Sci.*, i. p. 371.

A distinction must ever be kept in mind between the original writings of Aristotle and translations of them current in the thirteenth century. It is to translations that Bacon's remarks are directed; but there are also passages in his writings which show that he regarded the productions of the Stagirite as of no great authority. He classes together the ancient authorities appealed to in his day, and declares that their followers are full of doubts and obscurities, and are wanting in clearness; that they disagree with one another; that they start empty questions; that they lay down worthless sophisms; and that they give unsatisfactory accounts of operations and experiments.[2]

In reference to his own times, Bacon states, "Never was there so great an appearance of wisdom, nor so much exercise of study in so many faculties, in so many regions, as for these last forty years. Doctors are dispersed everywhere, in every castle, in every borough, and especially by the students of two orders," —the Franciscans and Dominicans—"which has not happened except for about forty years; and yet there was never so much ignorance, so much error."[3] A bad compliment this to his own as well as the other mendicant order. In connection with all this he deplores the neglect of mathematics, designated by him "the door and the key of the sciences."[4]

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[1] *Opus Majus*, p. 45.

[2] *Ibid.*, p. 10.

[3] Jebb's preface.

[4] *Opus Majus*, p. 57.

Amongst the men of his age, Roger Bacon stands out a miracle of learning. He was acquainted with Greek as well as Latin, with Hebrew as well as Greek. Nor was he unacquainted with the Arabic tongue. His writings show that he had studied mathematics, mechanics, optics, astronomy, geography, chronology, chemistry, astrology, music, medicine, grammar, logic, metaphysics, ethics, and, as we have seen, theology. He must have been in attainments a head and shoulders taller than his learned brethren. But it is not in book learning, not in the abundant stores of his capacious memory, not in the possession of the means and instruments of knowledge, that the pre-eminence of Bacon chiefly consists, but in his independence, originality, and clear-sightedness. He knew how to use what, with many of his contemporaries, seemed to be only so much lumber and incumbrance.

III. The *Opus Majus* of Roger Bacon was, as the title imports, his great work. It is divided into six parts.

First: He enters upon an inquiry into the causes of human ignorance, and he enumerates four: *authority, custom, popular opinion,* and *the pride of fancied knowledge.* These four causes of ignorance will at once bring to mind the four idols of Lord Bacon, but the two classifications do not correspond; they have not the same meaning, though the two writers are seen to move in somewhat the same track. And this will appear still more remarkably when we reach the close of the *Opus Majus.*

Upon the means of obtaining knowledge, Roger has much to say, and the discussion of this question occupies the remainder of the book. The first part being devoted to a description of the causes of ignorance, he skilfully proceeds to his next point, by contrasting the *fourfold* source of mischief with the *one* system of perfect wisdom, to which he assigns a primary place in the pursuit of knowledge, *i.e.* the study of Holy Scripture. This forms the second part of his treatise. He not only places Divine revelation as the crown of the arch of knowledge, inasmuch as men are to study it in order that they may learn the way of salvation, but he brings it into close relation with all scientific pursuits. He "strongly denounces the idea that philosophy and theology can be opposed to each other. True philosophy, he says, is not alien from, but is included in the wisdom of God. All wisdom is contained in Holy Scripture, but it must be explained by means of law and philosophy; and he protests against the injustice of condemning philosophy on account of the abuse made of it by persons who do not couple it with its end, which is the truth of Christ. On the one hand, we must use philosophy in the things of God, and on the other hand, in philosophy we must assume many things that are Divine."[1]

Thus, then, the knowledge of Scripture was to be combined with all other studies, and that not in the way which larger experience and riper wisdom would dictate. He had no idea of investigating philosophical questions upon independent grounds, assured that in the end it will be found there can be no contradiction between what God teaches in nature and what He teaches in revelation. In this respect many at the present day are no wiser than the Oxford friar.

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[1] Robertson's *History of the Church*, vol. vi. p. 476. He cites Bacon's *minor works*, as well as the *Opus Majus*, in support of this statement. As I have not seen the minor works, I use Canon Robertson's words.

The third part of the *Opus Majus* relates to the usefulness of grammar, including the study of languages; and in connection with this subject we may remark in passing, how he laments the neglect of the original languages of Scripture, and that children derived their knowledge, not from the Bible itself, but from versified abridgments, and how the Word of God suffered through the fault of translators. In short, he seems to have been an advocate for the general study of the Divine records; and thus, in the thirteenth century, he comes before us, so far, as a forerunner of John Wycliffe in the fourteenth.

The fourth part, one of the longest of all, is taken up with discussions on the importance of the study of mathematics. In fifteen chapters he shows how much mathematics have to do with the science and indeed with all the affairs and the occupations of this world, and then proceeds to maintain that they have also to do with the things which are Divine and heavenly; "this," he says, "is more to be considered, because what is human avails nothing till applied to that which is Divine."[1] He notices how mathematics are connected with astronomy, also how astronomy forms a part of Scripture, and is interwoven with many sacred questions. On this subject he is amazingly copious; so he is also on matters pertaining to chronology and the Church calendar. It is curious to find in what strange ways he brings his favourite study to bear on all kinds of subjects.

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[1] *Opus Majus*, p. 108.

In his treatment of mathematics in connection with science, he shows a just appreciation of their importance and value. Other sciences, he says, use examples derived from that source; and referring to the *Dialogues* of Plato, as quoted by Cicero, he remarks that the knowledge of mathematics is as it were innate, and that being in itself the easiest, it prepares the way to the most difficult knowledge; that mathematics are and must be in harmony with the facts of the physical world, and that in this domain of inquiry we attain to positive certainty. "There have been found," he remarks, "famous men, as Robert, Bishop of Lincoln, Robert Adam Marshman, and many others, who by mathematics have been able to explain natural causes, as may be seen in their writings; for instance, concerning the rainbow, comets, the generation of heat, the celestial bodies, and other subjects employed by theology and science."[1]

The fifth part of his treatise takes up, at very great length, the subject of perspective, and optics, the organs of vision, the straight lines of vision, its reflected and refracted lines, and the propagation of light and heat.

Then comes the sixth and last part, which deals with the question of experiment, invested in his estimation justly with so much importance. Experiment, he says, has three prerogatives, making it mistress and ruler of the sciences. It tests the noblest conclusions reached in other ways; it discovers truths which by no other means can be attained; and by its own power alone experiment can investigate the secrets of nature. And here it is most remarkable that Roger

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[1] *Opus Majus*, p. 64.

Bacon anticipates his namesake, Francis Bacon, in the use of the word *prerogativa scientiarum,* upon which Mr. Hallam justly remarks, "Whoever reads the sixth part of the *Opus Majus,* upon experimental science, must be struck by it as the prototype in spirit of the *Novum Organum.*"[1]

"There are two modes," says Roger Bacon, "of gaining knowledge, that is to say, by reasoning and experiment. Reasoning shuts up and brings us to conclude on an opinion, but it does not certify, it does not remove doubt, so that the mind can rest in the perception of truth, unless the mind finds it out by way of experience, because many have arguments which may be known, yet because they have not experience they neglect those arguments: they neither avoid bad ones, nor follow good ones. For if anybody who has seen fire should prove by sufficient argument that fire burns and destroys, never on that account would his mind acquiesce in the fact, neither would he avoid the fire before he had put his hand to it, or consumed something in it, so that by experiment he might prove what argument had taught; but experience having been gained, the mind attains certainty, and rests in the brightness of truth."[2]

The application of Bacon's principles to the phenomena of the rainbow is very admirable. He becomes poetical, as well as philosophical, when speaking of the drops which fall from the oars of the rower, as in the sunshine he dashes along with his boat, of the spray scattered by the mill-wheel, and of the dew on the summer morning meadows. And further, the form and height of the bow in the skies attract his attention. "He does not indeed trace the course of the rays through the drop, or account for the precise magnitude which the bow assumes; but he approaches to the verge of this part of the explanation, and must be considered as having given a most happy example of experimental inquiry into nature, at a time when such examples were exceedingly scanty."[1]

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[1] Hallam's *Middle Ages,* chap. ix., pt. 2.

[2] *Opus Majus,* p. 445.

Such then is a brief outline of the contents of the *Opus Majus*, a work of extraordinary ability and research, considering the age in which it was written.[2]

At the same time it must be noticed, that around the propitious gleams of truth which brighten and beautify the work, there lingers a large amount of what is ignorant and even absurd. Nobody can read, without smiling, a passage relative to the art of prolonging life. One of the wonderful preparations for the purpose consisted of dragon's flesh, a kind of food used by the Ethiopians, amongst whom there are good flying dragons; he tells us, "by the art which they possess they draw them out of their dens, and have bridles and saddles in readiness, and they ride upon them and make them bound in the air violently, so that the hardness and toughness of the flesh may be reduced, as boars are hunted by dogs and bulls are baited before they are killed for eating."[1]

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[1] Whewell, i. p. 377.

[2] It may be well here to indicate the proportions of one part to another.

Part I., on the Four Causes of Ignorance, extends from page 1 to page 22, in Jebb's folio edition, to which references are made in the present sketch.

Part II., on Holy Scripture as the one perfect wisdom, from page 23 to page 43.

Part III., on the Usefulness of Grammar, from page 44 to page 56.

Part IV., on the Importance of Mathematics, from page 57 to page 255.

Part V., on the Science of Perspective, subdivided into three parts, from page 256 to page 444.

Part VI., on the Science of Experiment, from page 445 to page 477.

Alchemy occupies a distinguished position amongst the ingenious and sometimes ludicrous disquisitions of this original philosopher; astrology too is a study which in his day held firm hold on the minds of many, nor was he free from its fascinating grasp. It is said, that were it not for the motes of dust which fill the air we should not see the sunbeam; and it has been also said that in this fact we have an illustration of "the intellectual world of thought. Alchemy was in itself nothing but darkness; it was mere dust and confusion; but it formed the motes of that dust which enabled mankind to see the light of the great science of chemistry. Astrology was also nothing but darkness and dust; but its dust also enabled mankind to see the first rays of the great sunbeam of astronomy."[2] But whatever there might be in Roger Bacon's mind of the ignorance and superstition of his times, throughout his writings we find him adopting a style of great independence, repudiating authority, appealing to mathematics and experiments, and manifesting the utmost liberty in reaching his conclusions. Nor can we here omit to notice his *implied* view of freedom of opinion. He nowhere lays down the broad principle of free inquiry; nowhere contends for the right of private judgment; nowhere asserts that men ought to have full latitude for expressing convictions; but he thinks and expresses himself as a free man, bound by no human authority; and when opposing error he distinctly says, addressing the pope, to whom he sent his book, "Let not your Serenity imagine that I intend to excite your Holiness, in order that the papal Majesty should *employ force against weak authors and the multitude, or that my unworthy self should raise any stumbling-block to study.*"[1]

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[1] *Opus Majus*, p. 470. [2] Stanley's *Funeral Sermon for Sedgwick.*

It is now proper to notice what has been said about his practical discoveries and inventions. The making of gunpowder has been attributed to the scientific friar. He certainly speaks of sulphur, charcoal, and saltpetre as ingredients in a detonating mixture, by which may be made a horrible noise like thunder;[2] but that he actually compounded and brought into use the substance now known as gunpowder has been questioned. Indians and Chinese, Arabs and Greeks, seem to have been acquainted with some sort of preparation like our gunpowder; and a receipt *de mixtione pulveris ad faciendum le Crake* forms part of the Spelman collection, mentioned by Sir Francis Palgrave; and another, *ad faciendum ignem Grecum,* is mentioned by the same learned author, both of a date perhaps before the thirteenth century.[3]

To Bacon has further been ascribed the invention of spectacles. He certainly seems to have been acquainted with the use of glasses. He describes them, and explains the magnifying properties of a convex glass; but when he says, "this instrument is useful to old persons who have weak eyes," perhaps he refers to an already known invention rather than to any contrivance of his own.

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[1] Quoted in Knight's *Biog. Dict.*, art. "Roger Bacon."
[2] *Opus Majus*, p. 474.
[3] *Merchant and Friar*, xxix., xxx.

The telescope is another invention about the origin of which there is a difference of opinion. Bacon studied the science of optics, and in the *Opus Majus* has this remarkable passage: "We can so shape transparent substances, and so arrange them with respect to our sight and objects, that rays can be broken and bent as we please, so that objects may be seen far off or near, under whatever angle we please; and thus from an incredible distance we may read the smallest letters, and number the grains of dust and sand, on account of the greatness of the angle under which we see them: and we may manage so as hardly to see bodies when near to us, on account of the smallness of the angles under which we cause them to be seen: for vision of this sort is not a consequence of distance except as that affects the magnitude of the angle. And thus a boy may seem a giant, and a man a mountain."[1] This passage seems to refer rather to such glasses as are used in a telescope, than to the completed instrument; and probably here Bacon was only throwing out one of those fruitful hints which his creative genius suggested. He was the very man to put others in the way of doing what he did not live himself to execute. He was here on the edge, if not the heart, of a theory afterwards to be reduced to useful practice in the service of astronomy. Between the simple idea started in the above extract and the contrivance of a modern telescope lies an enormous distance; still his prophetic thought went on the road by which at last the invention was reached.

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[1] *Opus Majus*, p. 474, translated in *Biog. Dict*, art. "Bacon."

That the suggestion proved of practical use long afterwards, is plain from a book by Thomas Digges, published in 1590. The author was an optician, and speaking of his father, says he constructed "perspective glasses, duly situate upon convenient angles, in such sort to discover every particular of the country round about, wheresoever the sunbeams might pierce, as since Archimedes (Bacon of Oxford only excepted) I have not read of any in action ever able by means natural to perform the like. Which," adds the writer, "partly grew by the aid he had by one old written book of the same Bacon's experiments, that by strange adventure or rather destiny came to his hands, though chiefly by conjoining continual laborious practice with his mathematical studies."[1]

From the time that Bacon began to apply himself to experimental philosophy, it would appear that he laid himself open to the suspicion of having communion with evil spirits. The Church denounced magic and necromancy, and whoever dabbled in these black arts rendered themselves liable to be burnt at the stake; but it would seem that in England the ecclesiastical courts were not so prying and active in this matter as in some countries, forasmuch as in parliamentary documents the name of *nigromauncer*[2] is found attached to some persons, as if it had been a legitimate calling. Still necromancy was a thing ecclesiastically unlawful, and a friar who was thought to dabble in practices of that kind excited the indignation and abhorrence of his brethren, and laid himself open to severe discipline and terrible punishment. But for a time no proceedings were instituted against Bacon, whatever might be the ill odour with which the ignorant Franciscans infected his reputation.

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[1] Art. "Roger Bacon," in Knight's *Biog. Dict.*

[2] *Merchant and Friar*, p. 346.

In 1267, when Bacon was above fifty-two years of age, he sent his *Opus Majus* to the pope, Clement IV., who had been papal legate in England, and had there heard of his learning and discoveries. He had expressed a wish to see Bacon's writings, and that wish was sufficient to justify the friar in sending his book to Rome, though the superiors of his order had forbidden its publication. The pope commanded him to forward the volume, notwithstanding any rule or judgment of his order to the contrary. The volume was accordingly forwarded by the hands of one of Bacon's favourite mathematical pupils.

For eleven years afterwards he was not subjected to any open persecution; but in 1278 the general of the Franciscan order, being appointed legate at the court of France, summoned the friar to appear before a council of the order, to answer charges brought against him. They were charges of insubordination to common rules, and of the practice of magic. Wild stories were told respecting him in after ages: as for example, that he constructed a brazen head, that he might learn from it how to enclose England with a thick rampart or wall; and that when consulting the oracle it suddenly burst in pieces, and shook the tower by the bridge to its very base, filling his assistant, and everybody else who heard of the catastrophe, with the utmost consternation. No doubt absurd reports respecting him flew about Oxford at the time he lived there, though what they were precisely nobody now can tell; and alleged facts of some kind in support of the charge of necromancy would be laid before the Franciscan officers sitting in council upon their poor brother.

Rome confirmed the proceedings of the council, and Roger was condemned to imprisonment. During ten years he petitioned for the restoration of his liberty, but all in vain; pope after pope neglected or refused the applications of the incarcerated philosopher. To Nicholas IV., the very person who, as general of the Franciscans, had presided at the council in 1278, Bacon sent a treatise on the method of resisting age and prolonging life, containing potent recipes like that given relative to Ethiopian preparations of dragon flesh. But the hope of a mollifying effect from the perusal of his writings was disappointed; indeed, Nicholas is reported to have increased the rigour of Bacon's confinement. Some say he died in prison; but other and better authorities inform us that he was set at liberty through the intercession of some noble persons, who sympathised with the captive, if not in his science at least in his sufferings. He returned to his old university, there wrote a treatise on theology, died probably in 1292, and was buried in the church of the Franciscans at Oxford.

It is easy to expatiate on the defects of this bold thinker. He sympathised in some of the absurd speculations and superstitious conclusions of his age. That he indulged in idle and grotesque fancies we have already seen. That he believed in astrology there can be no doubt; but as to what is understood commonly by magic, there exist no valid proofs that he addicted himself to its practice. Questions about alchemy are gravely discussed in his writings, but it must be remembered that "the perverse activity of the alchemists from time to time struck out a doubtful spark," and in the chemical experiments which alchemy included, "our illustrious countryman, Roger Bacon, shone out at the obscurest moment like an early star predicting dawn."[1] Some things done in the way of chemical experiment are related, and others remain unknown; and it is justly observed, that "the alchemists would have rendered essential service to chemistry had they only related their unsuccessful experiments as clearly as they have obscurely related those which they pretend to have been successful." [2] Bacon does not say that he had ever made gold himself, but, as he reports, others maintained that they had made it.

The inconsistency of some parts of his teaching, which favoured free inquiry, and the repudiation of authority, which he manfully expressed in his exposure of the first source of human ignorance, compared with other parts of his writings, in which he appears as a faithful and obedient son and servant of the Church, is in our eyes palpable enough. But no doubt, as we have said before, he could, and probably did, devise logical subtleties by which, to his own satisfaction, he made all such inconsistency disappear. In some respects he is liable to be misjudged. So far as he represented Scripture in its revelation of the will of God respecting the redemption of men; so far as he represented the duty and welfare of human beings as consisting in the humble and graceful acceptance of Divine truths, there could be no inconsistency whatever between such representations and the earnest independent study of nature, with a view to elicit secrets respecting facts and laws such as it is in the power of nature to yield. But, on the other hand, so far as he maintained the authority of the Church and its right to interpret Holy Scripture for its members; so far as he made the Church, thus interpreting Scripture, an oracle of science, such dogmas were utterly inconsistent with his philosophical principles, and with his appeals to facts and experiments as in themselves conclusive.

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[1] *Herschel*, p. 112.

[2] Macquer's *Dict. of Chemistry*, ix., quoted by Herschel.

A true estimate of Bacon's character, and the important lessons suggested by his life, demand and will repay the attention of thoughtful students. He was evidently a man before his age—one of those master spirits that can look above the level of a generation amidst which they live, and, endowed with a certain degree of prescience, can anticipate discoveries which to others are concealed in the womb of futurity. Animated by his profound reverence for the volume of revelation, and his devout study of its contents, he penetrated, though unconsciously, beyond the boundaries of common ecclesiastical thought, and, in all his inquiries on all questions, derived encouragement and stimulus from the conviction that there is, that there can be, no antagonism in the end between God's truth and men's loyal and honest researches into nature. The religious spirit which he cherished was a marked element in his character, and the use which he made of difficulties in the study of science as an answer to objections founded on the difficulties of religion, must never be forgotten.

Amidst all his researches he manifested alike the true humility of the philosopher who, ready to learn, is always willing to be taught, and the true humility of the Christian who, with a strong faith, recognises the existence of inexplicable mysteries, and waits for the revelations of another world. An advocate for truth, we see he was also an example of toleration and an apostle of charity. The persecutions he endured he would not retaliate. Though himself treated with violence, he told the pope that he did not wish to see the measure meted to him meted out to others who differed from him. With a calm faith in the progress of truth, he anticipated the future. He rejoiced in what had been done by others before him, and in what would be done by others when he was gone.

Rude and imperfect attempts would be followed by noble achievements, the day would come when what is unknown would be brought to light. One age does not suffice for inquiries so wide and various; in future times men will know many things unknown to us, and coming generations will marvel at our ignorance. So this sage and seer of the Middle Ages partook of the enlightened and liberal views of our own more favoured century; and at the end of his work he says: "We have seen how Aristotle, by the ways which wisdom teaches, could give to Alexander the wisdom of the world. And this the Church ought to take into consideration, against infidels and rebels, that there may be a sparing of Christian blood, and especially on account of the troubles that shall come to pass in the days of Antichrist; which by the grace of God it would be easy to obviate, if prelates and princes would encourage study, and join in searching out the secrets of nature and art."[1] His hopes for the Church and the world rested not on force, not on human authority, but on knowledge, persuasion, and charity.

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[1] *Opus Majus*, p. 477.

NICHOLAS COPERNICUS.

1472–1543.

THE treatment which Galileo received at the hands of Roman inquisitors has produced in some persons an intense prejudice against religion as inimical to science. The facts of the case are often misapprehended, and we shall have occasion to refer to them presently, when it will be our aim to state them with accuracy. In the meanwhile, it may be as well to remark, that the opposition of the Church of Rome to certain scientific conclusions no more proves any incompatibility between Christian faith and philosophical study, than the opposition of the same Church to the doctrines of the Reformation proves any incompatibility between Christian faith and the principles of Protestantism. It should be remembered, too, that Romanist persecution of religious reformers has been much more violent than any warfare ever waged by the Inquisition against scientific men.

The life of NICHOLAS COPERNICUS furnishes a signal example of the accordance between profound religious sentiment and the utmost inquisitiveness respecting the secrets of nature and the laws of the universe.

The birthplace of genius is sometimes found nestled amidst the fairest scenes; and the opening years of life are favoured with appeals to curiosity and imagination, such as stimulate the exercise of the intellect; but the lot of Copernicus, as a boy, was cast in one of the flattest, tamest, and most uninteresting parts of Germany. Not far from the banks of the Vistula, on the way to the free city of Danzig, lies a fortified town named Thorn, where the river is crossed by a wooden bridge, and the place is adorned by a bronze statue of our philosopher—for there he was born. His father was a merchant, and in the municipal records his father's name appears as a freeman admitted to the franchise in 1462. In 1472 or 1473 a son was added to the family; and the parents had a horoscope taken of the child, who appeared at thirty-eight minutes past four on the 19th of January, 1472, according to some, at forty-eight minutes past four in the afternoon on the 19th of February, 1473, according to others, the exact instant of the nativity being an important point in astrological calculations, which, in those days, inspired in fathers and mothers the deepest concern. At all events, Copernicus was deemed to have entered the world under a lucky planet, and it was augured that he would turn out a man of distinguished talent. About ten years before, Martin Luther studied at Mansfeld, and then at Eisenach, and rambled about the quaint streets, singing Christmas carols, in the town where he was born. Nicholas Copernicus passed through a similar course of education. He did so under some old-fashioned pedagogue, who no more dreamed of the scientific fame of his pupil than did Trebonius of the approaching celebrity of young Master Martin. Copernicus would there learn to read, to write, to construe Latin, and to commit to memory hymns, prayers, and catechisms. Whether as a lad he studied Greek is uncertain; but, as his parents seem to have been wealthy, he would enjoy greater advantages than his still more illustrious contemporary; hence at an early period he was sent to Cracow, where he studied philosophy, mathematics and medicine. Mathematics formed his favourite pursuit, and by the thorough acquisition of its principles and modes of reasoning he laid the basis of his subsequent eminence. But he took a degree as doctor of medicine; and, according to the comprehensive methods of culture which obtained in those days, he paid attention to painting, and made some proficiency as an artist. Scholars were at that period accustomed to travel, and Copernicus proceeded from Cracow to Bologna; and in that city of feudal palaces and towers he would find a school of painting to cultivate his artistic taste, as well as a university where he could study astronomy. There he entered upon divers calculations connected with the position of the earth and the plan of the heavenly bodies. Then proceeding to Rome, he became there a mathematical professor, and won vast renown. Soon after the commencement of the sixteenth century, he returned to the banks of the Vistula, and, having been ordained to the priesthood, had a canonry at Frauenburg, on the Frische Haff, bestowed upon him by his uncle. The cathedral is described as a handsome building of brick, erected in 1342, in an elevated part of the town, overlooking the flat sandbanks of the Elbing, as it flows on its way to the Baltic. In connection with his canonry, Copernicus had some contention about his official rights, the nature of which does not appear. All we know is that he settled down in that quiet, out-of-the-way corner of the world, heedless of worldly ambition, and indifferent to ecclesiastical honours and emoluments. He was no sceptic, no freethinker, nor do we find him taking a part in the theological controversies of his age. No mention is made of what he thought and did in relation to the grand quarrel between Luther and Leo, or the Diet of Worms, or the burning of the Bull at the gates of Wittenberg, or the other stirring events of the Reformation; only we know he remained a Catholic, a quiet, self-contained, thoughtful, devout man, childlike in his religion, trustful in his piety, and exemplary in the discharge of clerical duties. We can picture him going through the usual routine of canonical services in Frauenburg Cathedral, full of faith and prayer. With this vocation he coupled medical practice. He turned to good charitable account that proficiency in the healing art which he had acquired at Cracow, and visited the sick and the poor, bringing upon him the blessing of those who were ready to perish. But the nature of his intellect, sharpened by studies at Bologna and Rome, gave him special advantages in the pursuit of astronomical knowledge; and, as he had a decided taste in that direction, what time he could spare from the cathedral and the treatment of the sick he devoted to the study of the heavens. "He went very little into the world; he considered all conversation as fruitless except that of a serious and learned cast, so that he formed no intimacies except with grave and learned men." Alone at midnight he would watch the stars; in his study with his books he would inquire of the ancients; and then the profound thoughts passing through his mind he would exchange with the "grave and reverend seigniors" of his acquaintance.

The Ptolemaic hypothesis of the universe was then in fashion. It was supposed that the earth was the centre of celestial motions, that the sun, the moon and the stars revolved around the world which we inhabit. Not that the Pythagorean hypothesis was totally forgotten. There were those who believed that the sun, not the earth, is the centre of the great circle in which the heavenly bodies perform their evolutions; but the Ptolemaic hypothesis had the ascendency beyond all doubt; and with this hypothesis Copernicus could not rest satisfied. It appeared to him beset with insuperable difficulties. True enough, the rotation of the heavens around the earth *seemed* to be what the human eye beheld, as any one watched sunrise and sunset. But what the senses thus presented, reason, in its ponderings, was led to contradict. For the notion of a huge mechanism like the celestial sphere spinning round the terraqueous globe as its pivot looked unreasonable. To explain it in any way on mathematical principles needed a most complicated array of cycles and epicycles. Symmetry and simplicity were wanting in the theory. *A priori* objections started up against it. If the senses pointed to the earth as a centre, reason pointed to a centre elsewhere. Copernicus studied the works of ancient philosophers on the question. He examined mathematical traditions, and criticised the opinions of learned professors. He found accounts of those who had asserted the motion of the earth. "Though," he says, "it appeared an absurd opinion, yet, since I knew that in former times liberty had been permitted to others to figure as they pleased certain circles for the purpose of demonstrating the phenomena of the stars, I considered that to me also it might be easily allowed to try whether, by a supposition of the earth's motion, a better explanation might be found of the revolution of the celestial orbs. Having assumed," he goes on to say, "the motions of the earth by laborious and long observation, I at length found that if the motions of the other planets be compared with the revolution of the earth, not only these phenomena follow from the suppositions, but also that the several orbs and the whole system are so connected in order and magnitude that no one part can be transposed without disturbing the rest and introducing confusion into the whole universe."[1] What Copernicus was in search of was some simple and symmetrical theory of the appearances of the heavens, which would relieve him of the complexity and confusion attendant on the Ptolemaic system, so popular in the schools. He started from an *a priori* point of reasoning—the only one thought of in his day—but he came to certain conclusions which *a posteriori* examination in after times abundantly confirmed.

He believed that the earth is spherical:[2] that the earth and the sea constitute a wonderful globe: that the motions of the heavenly bodies are circular and uniform, or compounded of circular and uniform motions: that the earth revolves on its own axis, and also performs a journey along its own orbit round the sun: that the sphere of the fixed stars is immensely distant, and that it is impossible to explain the motion of the planets upon the supposition of the earth being their centre. And he distinctly remarks, "It does not shame us to confess that the whole space in which the moon revolves, together with the earth, moves along a great orbit amongst the planets, round the sun, every year; that the sun remains permanent and immovable, whatever may be its apparent motion."[1] It must be kept in mind throughout any careful study of his theory, that it was an *hypothesis* framed to remove difficulties connected with older systems; that he sought to bring conceptions of the universe into harmony with reason, instead of giving way to impressions made by the senses, or to the authority of world-honoured teachers, either in other days or in his own: nor can we omit adding that, whilst he found fault with the Ptolemaic cycles and epicycles, he constructed similar devices of his own. "As the real motions both of the earth and the planets are unequable, it was requisite to have some mode of representing their inequalities: and accordingly the ancient theory of excentrics and epicycles was retained so far as was requisite for this purpose."[2] In the case of Mercury's orbit he makes suppositions which are extremely complex, although they manifest his apprehension of the difficulties attendant on the common theory of his own time; but he verified many of his views by astronomical observations; and his approximations to modern science, and the light he threw on preceding discoveries, establish the fame of Nicholas Copernicus. He explains *the cause of the variation of the seasons* "rightly from the continued parallelism of the earth's axis. But he cannot obtain this parallelism from his mechanics. He imagines that if the globe of the earth move round the sun, and also round its own axis, the axis of rotation must always preserve the same inclination to the line joining the centre of the earth and sun, just as when a ball fastened by a string is made to spin, and a conical motion is simultaneously given to the string and ball. It is most evident that he got this idea from the solid crystal spheres. If the earth's axis were fixed in an immense sphere, with which it turned round the sun, and if in the first instance the axis produced would pass through the axis of the sphere, the complete phenomena of Copernicus would be produced. The earth's axis would then describe a cone yearly. To produce parallelism, Copernicus imagines what we may call an anticonical motion, namely, that the earth's axis is itself endued with such motion, independent of its motion in the sphere, as would, did it act alone, carry the axis round the same cone in a year, but the contrary way." At all events, whatever his method of procedure, and however it might be encumbered and weakened by lingering prejudices—the remnant of so much which he had mental vigour enough to get rid of—Copernicus certainly was the discoverer of the fact, that the variation of the seasons depends on the parallelism of the earth's axis, and "this explanation of the cause of the seasons must always place him among cosmical discoverers of the first order of sagacity."[1]

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[1] *De Revolutionibus Orbium Cœlestium*, preface.

[2] That is the starting-point of his book just cited.

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[1] *De Revolutionibus Orbium Cœlestium*, p. 9.

[2] Whewell's *History of Inductive Sciences*, i. p. 283.

The precession of the equinoxes[2] had been discovered by Hipparchus, a Greek philosopher. The subject is closely connected with that which has this moment been described; and by supposing the anticonical motion to be a little greater than the direct conical motion, still pursuing a hypothetical path, Copernicus arrived at what he conceived to be the *cause* of the precession of the equinoxes. It has been fairly remarked, in connection with this subject, that if we consider that even Newton himself, in tracing the effect of causes producing the precession, is thought to have misapprehended somewhat his own laws of motion, it is not to be wondered at that the mechanics of Copernicus should at this point be open to question.[1]

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[1] Knight's *Cycl. Biography*, art. "Copernicus."

[2] "The slow backward motion of the equinoctial points along the ecliptic annually caused by the action of the sun, moon

The stations and retrogradations of the planets he made out after a method similar to that now adopted by astronomers, so far as the qualities of the phenomena are concerned; the method of rectifying the quantities, in the judgment of scientific critics, was involved in his theory relative to the parallelism of the axis of planetary bodies, as it appears in his teaching with regard to the rotation of the earth on its axis, and the

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and planets upon the protuberant matter about the earth's equator, in connection with its diurnal rotation." The name is given "because either equinox, owing to its westerly motion, comes to the meridian sooner each day than the point it would have occupied without the motion of precession, and thus precedes that point continually, with reference to the time of transit and motion" (Webster). Sir J. F. W. Herschel explains the phenomenon in his *Astronomy*, p. 168, and says, "It has acquired the name of *the precession of the equinoxes* because the place of the equinox among the stars at every subsequent moment precedes (with reference to the diurnal motion) that which it held the moment before." This fact renders a reconstruction of the astronomical chart necessary after the lapse of a number of years.

[1] Knight's *Cycl. Biography*, art. "Copernicus."

inclination of that axis to the line drawn from its own centre to the centre of the sun. Here we may notice that it was objected to by the supporters of the Ptolemaic system, on the ground that if Copernicus were correct Venus should sometimes appear horned like the moon. "To this he answered by admitting the conclusion, and averring that, should he ever be able to see its actual shape, it *would* appear so. It is easy to imagine with what force the application would strike every mind when the telescope confirmed this prediction, and showed the planet just as both the philosopher and his objectors had agreed it ought to appear."[1]

With respect to *the almost entire absence of all parallax* in the fixed stars, (*i.e.* an apparent displacement of an object caused by a change of position on the part of an observer), Copernicus came to the conclusion that the distance of the earth from the sun has no apparent magnitude when compared with the sphere of the fixed stars: "all which things," he adds, "though they be difficult and almost inconceivable, and against the opinion of the majority, yet, in the sequel, by God's favour, we will make clearer than the sun, at least to those who are not ignorant of mathematics."[2]

Further, "one of the most remarkable passages in Copernicus is his conjecture that *gravitation was not a central tendency*, as had been supposed, but an attraction common to matter, and probably extending to the heavenly bodies, though it does not appear that he surmised their mutual influences in virtue of it."[3]

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[1] Herschel's *Discourse on the Study of Natural Philosophy*, p. 269.

[2] Whewell, *Hist. Induct. Sciences*, i. p. 282.

[3] Gassendi, *Vita Copernici*. Hallam, *Int.*, etc., i. p. 636.

Copernicus's own words, literally rendered, are, "gravitation is a tendency (*affectio*) not of the whole earth, but of each part; and it may be believed to extend to the sun and the moon and the stars."

But, whilst anxious to do justice to Copernicus, and having followed the best authorities we can find on the subject of his discoveries, we would guard against any over-estimate of the extent and worth of his original scientific opinions. We repeat, therefore, and would emphasize the word *approximation*—for, taking his actual discoveries at the highest possible rate, they were *approaches* to a philosophy,—afterwards firmly established by observation, and clearly illustrated by the application of general principles,—rather than a full attainment of it as we find it unfolded by Newton and others.

On a review of the life of Copernicus, and the conclusions he reached, the mental and moral qualities of the man come out with conspicuous and extraordinary lustre.

He was a mathematician, thus walking in the footsteps of Roger Bacon. This science, since the days of Euclid, had been pursued with untiring ardour, and many who neglected to study, or who, by their own imagination, distorted the actual phenomena of nature, addicted themselves to the investigation of the abstract properties of magnitude and number. Copernicus, in his knowledge of mathematical principles and in his skilful application of them to astronomical inquiries, probably surpassed all his contemporaries. And, at the same time, he had that inventive genius which is fruitful in suggestions, such as become pioneers in the path of scientific demonstration. Though guesses can never satisfy a philosopher, guesses may put him in the way of reaching what is capable of positive proof. "The tendencies of our speculative nature, which carry us onward in the pursuit of symmetry and rule, and which thus produced the theory of Copernicus, as they produced all theories, perpetually show their vigour by overshooting their mark. They obtain something by aiming at much more. They detect the order and connection which exist by imagining relations of order and connection which have no existence." "To try wrong guesses is apparently the only way to hit upon right ones."[1] His independence of mind, his real originality, and his boldness in the pursuit of truth, are quite as remarkable as the qualities just noticed; indeed, they are involved in or they led to the latter of these. "I beg you," says one of his admiring disciples, "to have this opinion concerning that learned man my preceptor, that he was an ardent admirer and follower of Ptolemy; but when he was compelled by phenomena and demonstration, he thought he did well to aim at the same mark at which Ptolemy had aimed, though with a bow and shaft very different from his. We must recollect that Ptolemy says, 'He who is to follow philosophy must be a freeman in mind.'"[2] Copernicus knew very well that there were many prepared to challenge his conclusions—perhaps to bring theological objections to the principles of science which he had been constrained to adopt. "If perchance," it is said in the preface to his book on astronomy, "there be vain babblers, who, knowing nothing of mathematics, yet assume the right of judging, on account of some place of Scripture, perversely wrested to their purpose, and who blame and attack my undertaking, I heed them not, and look upon their judgments as rash and contemptible."

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[1] Whewell, *Hist.*, i. p. 284.

[2] Rheticus, quoted by Whewell, *Hist.*, p. 286.

Copernicus had a profound reverence for Scripture. He regarded it as the Word of God, able to make us wise unto salvation; and none of his discoveries pertaining to the laws of nature shook for one moment his confidence in the revelation of the gospel. Early does he appear to have distinguished between the teaching of the Divine oracles as to the redemption of the world by Jesus Christ, and those passages which relate to physical facts, and the appearances to popular apprehension. With respect to the latter, when urged against clear scientific deductions, he raised important inquiries as to the interpretation of Scripture. What does the book really say, and how is it to be fairly and fully explained? Vain babblers might wrest certain texts, so as to place them at war with the facts of the universe; but a course of that kind could not settle any controversy as to the relation between science and the two Testaments. But with all his boldness he had patience. "He that believeth shall not make haste" is as true in philosophy as in religion. The man of true faith, whether it touches natural or spiritual things, can afford to wait and in patience possess his soul. Copernicus delayed for years the publication of his discoveries to the world. That delay has been thought to have proceeded from something like fear, or, at least, caution, lest views in some respects so novel should rouse ecclesiastical antagonism and expose him to serious persecution. But the words used in the dedication of his astronomical work seem to point in another direction. It is there said that he had kept it four times the nine years recommended by Horace, and published it at last in compliance with the entreaties of his friend Cardinal Schomberg. "Though I know," it is added, "that the thoughts of a philosopher do not depend on the judgment of the many, his study being to seek out truth in all things as far as that is permitted by God to human reason, yet when I considered how absurd that doctrine would appear, I long hesitated whether I should publish my book, or whether it were not better to follow the example of the Pythagoreans and others, who delivered their doctrines only by tradition and to friends." From this passage we should infer that he apprehended controversy rather than persecution—that for the former he had no desire, that he was without ambition, and felt no wish to found a new school, but would rather leave truths he had learned quietly to make their way through the world.

The adoption of the Copernican theory was cautious and of slow advancement. The celebrated Leonardo da Vinci, who painted the Last Supper on the walls of the monastic refectory at Milan, and who united together science and art, entertained the idea of the earth's rotation. Giordano Bruno had a large share in the credit of introducing Copernican ideas into England; but Lord Bacon never gave to them his "cordial assent;" and Milton puts into Adam's lips the difficulties of the Ptolemaic hypothesis, which are indeed answered by Raphael, who also suggests:

"What if, seventh to these,
The planet earth, so steadfast though she seems,
Insensibly three different motions have?"

And again the poet says:

> "Or she from west her silent course advance,
> With inoffensive pace, that spinning sleeps
> On her soft axle while she paces even,
> And bears thee soft with the smooth air along."

It is remarkable that the chief English defender of the new views in England was no sceptical philosopher, but the orthodox Bishop Wilkins, who, in 1640, published his *Discourse Concerning a New Planet, tending to prove that it is probable our Earth is one of the Planets.* In this work he takes up objections drawn from Scripture, and shows that they are misapprehensions of the Divine meaning, which itself is not contrary to his own scientific opinions. Seth Ward also, another orthodox English bishop, appears in the advance guard of Copernican believers.[1]

Galileo, as everybody knows, walked in the footsteps of Copernicus, and made astronomical discoveries of his own, which, in the end, landed him in immense trouble. His doctrines were opposed on theological grounds; but this occurred nearly a century later than the period when Copernicus first broached his new system. Times had altered. The Reformation had occasioned an age of bitter controversy, and the powers at Rome were sniffing after any heretical scent which could be caught among the professed members of the Church. What might be allowed to pass in 1500 could not be endured in 1600. "It appears to me," says Dr. Whewell, "that the different degree of toleration accorded to the heliocentric theory in the time of Copernicus and of Galileo, must be ascribed, in a great measure, to the controversies and alarms which had in the meantime arisen out of the Reformation in religion, and which had rendered the Romish Church more jealous of innovations in received opinions than it had previously been."[1] Certainly the publication of novel scientific doctrines met with an opposition in Italy to which they were not exposed elsewhere; and Kepler, writing to Galileo in 1597, told him that Italy was no fit place for the promulgation of his principles. Recent researches have considerably modified the old story of Galileo's persesecution. It appears now that his attitude from the beginning was submissive; that in 1616 the Inquisition simply pronounced the Copernican doctrine contrary to Scripture; that then, silence was not actually enjoined upon him, a fact however afterwards falsified; that at the second trial, in 1632, he was threatened with torture which was not executed; that he recanted at command without really altering his opinion; and that the story of his eyes being put out, of the hair-shirt, and of *E pur si muove,* is altogether without foundation. Still the narrow-minded bigotry of Rome remains what it was; it should also be added that a tardy submission to the inevitable did not come until 1822, when the general opinion of modern astronomers was allowed to be published in Rome.[2]

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[1] See Whewell, *Hist.*, pp. 292–299.

The fame of Copernicus is now wide as the world. He painted a portrait of himself, which fell into the hands of Tycho Brahe; and he wrote an epigram upon the subject, to the effect that the whole earth could not contain the whole of the man who whirled it along the ocean of ether. Less extravagant was the grateful enthusiasm of Rheticus, a disciple of Copernicus, already mentioned, when he wrote, "God has given to my excellent preceptor a reign without end; which may He vouchsafe to guide, govern, and increase, to the restoration of astronomical truth. Amen!"

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[1] *History of Inductive Sciences,* i. p. 304.

[2] *Galileo Galilei,* etc., by Karl Von Gebler, 1879. See p. 89

"The Copernican system" is the name now generally given to the almost universal scientific belief that the earth and the planets revolve round the sun, though the system carried out and perfected by Kepler, Newton, Halley, Laplace, and others is by no means perfectly identical with the theory of the German astronomer. But the inextricable interweaving of his name with opinions sanctioned by the entire scientific world is one of the noblest conceivable tributes to the magnitude and lustre of his renown.

His death was in harmony with his life. Shortly before he expired he repeated these words:

> "Non parem Paulo gratiam requiro,
> Veniam Petri neque posco; sed quam
> In crucis ligno dederat latroni
> Sedulus oro."[1]

He had lived a life of Christian virtue,—imitating his Master, who went about doing good, healing the sick and preaching the gospel to the poor,—yet, so far from having anything whereof to boast before God, he said himself that he felt his need of infinite mercy; and in seeking the pardon of his sins he would not place himself on a level with Paul or Peter, but rather choose a point of self-humiliation by the side of the penitent thief.

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[1] Chalmers's *Biographical Dictionary*, art. "Copernicus."

His work on the revolution of the celestial bodies was passing through the press at the time of his fatal illness in 1543, when he had completed his seventieth year, and was brought to him just before he breathed his last; and thus, as has been beautifully expressed, he was "made to touch the first printed copy of his book when the sense of touch was gone, seeing it only as a dim object through the deepening dusk."[1]

He is buried under a flat stone in one of the side aisles of his own cathedral at Frauenburg. On his monument is painted a half-length portrait, pale, thin, aged, but with an expression of countenance intelligent and pleasant. His hair and eyes are black; he is habited as a priest; his hands are joined in prayer; before him is a crucifix; at his feet a skull, and behind him are a globe and a pair of compasses. His devotion, his deadness to the world, and his love of science are thus aptly symbolized.

Ecclesiastical distinctions were beautifully merged in the publication of the volume already mentioned. Copernicus was a Roman Catholic. The editor was no other than Andrias Osiander, the renowned German Protestant, present at the Diet of Augsburg, and one of the early coadjutors of Martin Luther, though in some important respects he afterwards diverged from his theological opinions. The preface was written by Osiander in the name of Copernicus, not by Copernicus himself, as is sometimes supposed; yet probably it contains matter taken from the author's MSS. Emphasis is there given to the idea that hypotheses are allowable for the explanation of nature without affirming that they actually correspond with known facts. "It is not necessary that hypotheses should be true or even probable; it is sufficient that they lead to results of calculation which agree with observations." With this caution, lest the book should be open to accusations of heresy, and with the imprimatur of a cardinal, as well as with a dedication to the pope, there was associated on the title-page a most curious puff and a recommendation to purchase, perhaps unparalleled. The following is a translation:

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[1] *Daniel Deronda,* iii. p. 267.

"Six books of Nicholas Copernicus, of Thorn, concerning the revolutions of the heavenly bodies. You have in this volume, recently prepared and edited, studious reader, the motion of the stars, fixed and erratic, according to ancient and modern observation, and illustrated by new and admirable hypotheses. You have also convenient tables by which you may calculate most easily. Therefore buy, read, and improve. Let no one ignorant of geometry open the book."[1]

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[1] The work is a small folio, and is divided into six books, prefaced by an address to the reader on the hypotheses propounded in the work; a kind of imprimatur by Cardinal Schonbergius, and a preface or dedication to Pope Paul III. The last is entitled *Præfatio Authoris*, though written by Osiander. The volume abounds in diagrams and mathematical calculations. The copy used in this sketch is in Dr. Williams's Library.

FRANCIS BACON.

1561–1626.

THE pre-eminent position in the annals of science occupied by LORD BACON renders it necessary that we should study the relation in which he stands to the subject of this volume. As philosophy was one main business of his life, and as his views of religion are plainly expressed in his works, he affords a signal example bearing on our theme; in that respect only does he come within the range of our notice. To attempt here a memoir of Bacon, under the different aspects which his biography should assume, is out of the question. As a lawyer his history must be judicial; as a statesman it must be political; as a man of high rank and vast power he requires to be socially considered in relation to the times when he lived, and the men amongst whom he moved; and his moral character, one is sorry to say, would require a deep and diversified method of inquiry, demanding examination of evidence, and a careful application of acknowledged rules of conduct to a special and extraordinary case.

A summary of the facts of Bacon's story is given in Lord Campbell's *Lives of the Chancellors,*[1] in a manner so admirable and eloquent as to form one of the finest passages to be found in our biographical literature; it may be fitly introduced as a preface to our limited review.

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[1] Vol. iii. p. 1.

"He has often been eulogised and vituperated; there have been admirable expositions of his philosophy and criticisms on his writings; we have very lively sketches of some of his more striking actions; and we are dazzled by brilliant contrasts between his good and bad qualities, and between the vicissitudes of prosperous and adverse fortunes which he experienced. But no writer has yet presented him to us familiarly and naturally from boyhood to old age—shown us how his character was formed and developed—explained his motives and feelings at the different stages of his eventful career; or made us acquainted with him as if we had lived with him, and had actually seen him taught his alphabet by his mother; patted on the head by Queen Elizabeth; mocking the worshippers of Aristotle at Cambridge; catching the first glimpses of his great discoveries, and yet uncertain whether the light was from heaven; associating with the learned and the gay at the court of France; devoting himself to Bracton and the Year Books in Gray's Inn; throwing aside the musty folios of the law to write a moral essay, to make an experiment in natural philosophy, or to detect the fallacies which had hitherto obstructed the progress of useful truth, contented for a time with taking 'all knowledge for his province;' roused from these speculations by the strings of vulgar ambition; plying all the arts of flattery to gain official advancement by royal and courtly favour; entering the House of Commons, and displaying powers of oratory of which he had been unconscious; being seduced by the love of popular applause, for a brief space becoming a patriot; making amends by defending all the worst excesses of prerogative; publishing to the world lucubrations on morals which show the nicest perceptions of what is honourable and beautiful as well as prudent in the conduct of life; yet, the son of a Lord Keeper, the nephew of the prime minister, a queen's counsel, with the first practice at the bar, arrested for debt, and languishing in a sponging-house, tired with vain solicitations of his own kindred for promotion, joining the party of their opponents, and after experiencing the most generous kindness from the young and chivalrous head of it, assisting to bring him to the scaffold, and to blacken his memory; seeking by a mercenary marriage to repair his broken fortunes; on the accession of a new sovereign, offering up the most servile adulation to a pedant whom he utterly despised; infinitely gratified by being permitted to kneel down, with 230 others, to receive the honour of knighthood; truckling to a worthless favourite with the most slavish subserviency, that he might be appointed a law officer of the crown; then giving the most admirable advice for the compilation and emendation of the laws of England, and helping to inflict torture on a poor parson, whom he wished to hang as a traitor for writing an unpublished and unpreached sermon; attracting the notice of all Europe by his philosophical works, which established a new era in the mode of investigating the phenomena both of matter and mind; basely intriguing in the meanwhile for further promotion, and writing secret letters to his sovereign to disparage his rivals; riding proudly between the Lord High Treasurer and Lord Privy Seal, preceded by his mace-bearer and purse-bearer, and followed by a long line of nobles and judges, to be installed in the office of Lord High Chancellor; by-and-by settling with his servants the accounts of the bribes they had received for him; a little embarrassed by being obliged out of decency, the case being so clear, to decide against the party whose money he had pocketed, but stifling the misgivings of conscience by the splendour and flattery which he now commanded; struck to the earth by the discovery of his corruption; taking to his bed, and refusing sustenance; confessing the truth of the charges brought against him, and abjectly imploring mercy; nobly rallying from his disgrace, and engaging in new literary undertakings, which have added to the splendour of his name; still exhibiting a touch of his ancient vanity, and in the midst of pecuniary embarrassment refusing to 'be stripped of his feathers;' inspired, nevertheless, with all his youthful zeal for science in conducting his last experiment of 'stuffing a fowl with snow to preserve it,' which succeeded 'excellently well,' but brought him to his grave; and, as the closing act of a life so checkered, making his will, whereby, conscious of the shame he had incurred among his contemporaries, but impressed with a swelling conviction of what he had achieved for mankind, he bequeathed his 'name and memory to men's charitable speeches, to foreign nations, and the next ages.' "

He, Francis, was the youngest son of Sir Nicholas Bacon, Lord Keeper of the Great Seal for twenty years under Queen Elizabeth. Born in 1561, he went to Trinity College, Cambridge, in his thirteenth year, and studied under Whitgift, afterwards Archbishop of Canterbury, manifesting, even as a lad, a strong antipathy to Aristotle, whose philosophy, he said, was only strong for disputations and contentions, but barren of works for the life of man. It is added that though ever retaining a low opinion of the Stagirite's method, he ascribed high attributes to the man himself.

Being intended for the legal profession, Bacon went from Cambridge to Gray's Inn, London, and there divided his time between law and philosophy. Having enlarged his knowledge of men and things by foreign travel, he returned to his favourite study, and began, even before he came of age, to prepare an essay on what he entitled *The Greatest Birth of Time,* in which thoughts were recorded serviceable to him in the immortal work which employed his best powers, and crowned his loftiest fame. Though successful at the bar, for he was a good lawyer and an eloquent pleader; though early made, as we should say, a Q.C.; though a member of parliament, and then gradually rising in his profession until, in 1618, he reached the woolsack, he all the way through his legal and political career kept his eye fixed on philosophy. He published his *Essays* in 1597; his *Advancement of Learning* in 1605; his *Wisdom of the Ancients* in 1610; and his *Novum Organum* in 1620. When reading the public life of Bacon through all these years, following him through all his employments, intrigues, perplexities, and disappointments, it is marvellous to think of his having achieved, *under such circumstances,* the task of writing such books, and launching into the world a new system of philosophy.

His great work, called *Instauratio Magna,* now demands our attention. Twelve times revised, but at last left incomplete, he published it with the statement that he had spent upon it thirty years of his life. The accounts sometimes given of it are confused, owing to the manner in which it was published. We shall describe it as presented in Montague's edition, vols. viii. and ix. It is written in Latin, and is divided into six parts. The first part is entitled, "De Dignitate et Augmentis Scientiarum Libros ix.;" and after the first book come eight others, relating to what Bacon calls *partiones scientiarum.*[1] These contain a summary of existing human knowledge. In reference to this subject Hallam remarks: "This wonderful man, in sweeping round the champaign of universal science, with his powerful genius, found as little to praise in the recent as in the ancient methods of investigating truth. He liked as little the empirical presumption of drawing conclusions from a partial experience as the sophistical dogmatism which relied on unwarranted axioms and verbal chicane."[2] The second part contains the *Novum Organum,* which he describes as the science of a better and more perfect use of reason in the investigation of things, and of the true aids of the understanding. The fundamental principle of his philosophy he states in the oft-quoted words, "Man, the servant and interpreter of nature, can only understand and act in proportion as he observes or contemplates the order of nature; more he can neither know nor do."

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[1] The *partiones* extend over vol. viii. and part of vol. ix. of Montague's edition.

[2] *Introduction to the Lit. of Europe,* iii. p. 167.

Much of the ignorance and misapprehension of mankind Bacon attributes to four causes—prejudices that arise out of human nature itself, which he denominates the images or illusions of the tribe or race; prejudices arising out of individual idiosyncrasies, called illusions of *the den or cave,* the innermost part of a man's own mind; prejudices belonging to the imperfection of language, termed illusions of *the market-place,* from the market-place being a centre of resort, where words—most troublesome things—are exchanged; and prejudices pertaining to philosophical theories, fancifully designated illusions of *the theatre,* because the theatre exhibits fictitious dramas.[1] Afterwards, in unfolding *his inductive* method, he speaks of *prerogative instances,* using, so far, the terminology of his namesake, the Friar: however we may account for the coincidence, it exists. Then come the aids of induction, next comes the rectification of induction. These discussions are followed by remarks on varying investigation, according to the nature of the objects investigated; on the boundaries of human knowledge and inquiry; on a synoptical view of nature in general; on the application of inquiry to practice; on preparations for inquiry; and on what he calls the ascending and descending scale of axioms. With regard to some of these particular topics we are at a loss to determine all the author means, as after the first division, which is somewhat amplified, he contents himself with a bare enumeration of subjects.[1] The third part of the *Instauratio Magna* relates to natural history, in which a number of facts are recorded from experience and observation, touching a variety of ways in which human art has been employed on the rough materials of nature. A thousand observed facts and experiments are included in his *Centuries of Natural History,* but very little of the vast outline sketched in the *Novum Organum* is filled up in that work; and as Bacon himself was no great experimentalist, and as his slight acquaintance with mathematics did not qualify him for carrying out astronomical and other inquiries, nothing very valuable in that direction could be looked for from him. His enumeration of matters to be inquired into seems to us rather odd,—the history of winds, of life and death, of density and rarity, of sound and hearing. The fourth part he calls "Scala Intellectus," of which he gives a few pages, observing, "By these tables we mean not such examples as we subjoin to the several rules of our method, but types and models which place before our eyes the entire process of the mind in the discovery of truth, selecting various and remarkable instances." The fifth part, entitled, "Anticipationes Philosophiæ," is a mere fragment, giving little idea of his large expectations; but what he advances he quaintly describes as "the payment of interest till the principal could be raised." The sixth and last portion, intended to display a full system of philosophy, is very meagre. "To perfect this last hope," he says, "is above our powers. We may, as we trust, make no despicable beginning; the destinies of the human race must complete it; in such a manner, perhaps, as men, looking only at the present, would not readily conceive. For upon this will depend not only a speculative good, but all the fortunes of mankind and all their power."

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[1] The *Novum Organum* is written in the form of aphorisms.

From 45 to 53 they relate to the idols of the tribe.
From 53 to 59 to the idols of the den.
From 59 to 61 to the idols of the market.
From 61 to 68 to the idols of the theatre.
These aphorisms in the English translation extend from pp. 37–49 of Montague's edition, vol. xiv.

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[1] The *Novum Organum* is translated in vol. xiv. of Montague's edition. An account of the *Novum Organum* has been published by the Useful Knowledge Society. Here, as elsewhere, I have consulted Hallam's *Introduction,* iii. pp. 166–198. What Bacon says as to *prerogative instances* will be found in the translation of the *Novum Organum,* works, xiv. pp. 125–210. The Latin text is contained in vol. ix. pp. 339 *et seq.*

A person who has only heard of Bacon's inductive philosophy will feel disappointment in turning over the pages of some parts of his wonderful work; for Bacon deals in aphorisms briefly expressed, with terms in them "hard to be understood," though pregnant with meaning when carefully considered. His order of thought has at times a strange appearance, and his selection of instances is not of an obvious kind. His treatise after the earlier part is a skeleton-like one. He begins, but does not finish, encloses vast plots of ground on which you think he will build stately edifices, whereas he only marks out streets and houses, as it were, on a rough map. In short, there are promises of things without the things themselves. Many books are exhaustive, in the sense of emptying entirely all which existed in the author's mind—he is exhausted, not his theme. But on pondering Bacon's aphorisms, the reader sees how very much more of meaning there is in his words than at first appears; and what an enormous quantity of reflectiveness, speculation, and truth lay behind what the author had time and power to express. His work was mainly preparative. "He was the miner and sapper of philosophy, the pioneer of nature; and he eminently promoted the dominion of man over the material world. He was the priest of nature's mysteries; and he taught men in what manner they might discover her profoundest secrets, and interpret those laws which nature has received from the great Author of all."[1]

"Let us now see what Lord Bacon's method really was. He has given it the name of induction, but carefully distinguishes it from what bore that name in the old logic, that is, an inference from a perfect enumeration of particulars to a general law of the whole. For such an enumeration, though of course conclusive, is rarely practicable in nature, where the particulars exceed our powers of numbering. Nor, again, is the Baconian method to be confounded with the less complete form of the inductive process, namely, inferences from partial experience in similar circumstances, though this may be a very sufficient ground for practical, which is, probable knowledge. His own method rests on the same general principle, namely, the uniformity of the laws of nature, so that in certain conditions of phenomena the same effects or the same causes may be assumed; but it endeavours to establish these laws on a more exact and finer process of reasoning than partial experience can effect. For the recurrence of antecedents and consequents does not prove a necessary connection between them, unless we can exclude the presence of all other conditions which may determine the event. Long and continued experience of such a recurrence, indeed, raises a high probability of a necessary connexion; but the aim of Bacon was to supersede experience in this sense, and to find a shorter road to the result; and for this his methods of exclusion are devised. As complete and accurate a collection of facts, connected with the subject of inquiry, as possible is to be made out by means of that copious natural history which he contemplated, or from any other good sources. These are to be selected, compared, and scrutinized, according to the rules of natural interpretation delivered in the second book of the *Novum Organum,* or such others as he designed to add to them; and if experiments are admissible, these are to be conducted according to the same rules. Experience and observation are the guides through the Baconian philosophy, which is the handmaid and interpreter of nature. When Lord Bacon seems to decry experience, which in certain passages he might be thought to do, it is the particular and empirical observation of individuals, from which many rash generalizations had been drawn, as opposed to that founded on an accurate natural history. Such hasty inferences he reckoned still more pernicious to true knowledge than the sophistical methods of the current philosophy; and in a remarkable passage, after censuring this precipitancy of empirical conclusions in the chemists, and in Gilbert's *Treatise on the Magnet,* utters a prediction that if ever mankind, excited by his counsels, should seriously betake themselves to seek the guidance of experience instead of relying on the dogmatic schools of the sophists, the proneness of the human mind to snatch at general axioms would expose them to much risk of error from the theories of this superficial class of philosophers." [1]

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[1] Account of the *Novum Organum,* Useful Knowledge Society, p. 3.

Bacon spoke disparagingly of the doctrine of final causes, or evidences of design in the works of nature; and both in reference to science and natural religion many persons in the present day eagerly lay hold on this circumstance, and with it strive to blunt the edge of what are called the teleological arguments. Bacon compares final causes in physics to the Vestal virgins of old, who bore no offspring. Yet, in physiology, most great discoveries have sprung from certain assumptions as to the purposes of things. Perhaps,—it has been acutely suggested,—if the great philosopher had taken occasion to expand his figure, he would have said that the barrenness of final causes, like that of Vestal virgins, was no reproach, "seeing they ought to be not the mothers, but the daughters of our natural sciences; and that they were barren, not by imperfection of their nature, but in order that they might be kept pure and undefiled, and so fit ministers in the temple of God." The author of this striking remark adds, "In physiology, if they are not mothers, they are admirable nurses: skilful and sagacious in perceiving the signs of pregnancy and helpful in bringing the infant truth unto the light of day." [2]

There has been much controversy as to the originality and usefulness of Bacon's method, some contending that induction is a natural process which men have pursued from the beginning, and that the practical value of his maxims has been over-estimated. But surely it is no objection to a method, that it is natural; and the originality of Bacon consisted in laying hold of a fact based on the common faculties of the human mind, and in explaining the principle it embodied. The practical value of the method, or rather the rule he laid down respecting it, is this, that he taught men to do wisely in perfection what they had been in the habit of doing unwisely and imperfectly.

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[1] Hallam's *Int.* iii., p. 177.

[2] Whewell's *Hist. of the Inductive Sciences*, iii. p. 561.

The fruitfulness of Bacon's philosophy is shown when we consider *how it was accepted at the time.* Contemporaries felt the depth of wisdom contained in his numerous writings, and vied with each other in the fervour of their laudations. Ben Jonson, Sir Henry Wotton, Dr. Heylin, and the University of Oxford were loud in his praise; and a letter from Italy to Lord Cavendish, afterwards Earl of Devonshire, declared that Lord Bacon was "more and more known, and his books more and more delighted in; so that those men who had more than ordinary knowledge in human affairs esteemed him one of the most capable spirits of that age."[1]

And this is very noteworthy, that foreigners seem to have known or thought nothing of his moral inconsistencies, so absorbed were they in their admiration of his intellectual greatness. Whilst he was living, eminent persons crossed the seas on purpose to see him and talk with him; afterwards encyclopædists gathered up what was to their taste respecting his character and works, but even Bayle, omnivorous as he was in his appetite for slander, though he alludes to Bacon's poverty, passes over in silence the criminal charges against him as Lord Chancellor. Contemporary with him were Gassendi and Descartes, and they both mention him—the former with warm admiration; Richelieu and Voiture held him in high esteem. The *De Augmentis* was republished in France 1624, and translated 1632. Three editions were issued in Holland between 1645 and 1662. The *Novum Organum* also appeared in Dutch three times, 1645, 1650, and 1660. Leibnitz and Puffendorf were loud in its praise.

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[1] Quoted with other testimonies in Alibone's *Dictionary* art. "Francis Bacon."

All successful inquiries into nature after Bacon's time have proceeded on the principles which he laid down. The unanimity with which men accepted his doctrines and made use of them is remarkable. In astronomy Newton walked in the footsteps of Bacon. In chemistry Boyle did the same. In magnetism Gilbert adopted the Baconian induction; and in electricity Priestley followed in the same track. The march of science for two centuries and a half has received an impetus, and has proceeded along a line laid down by the Lord of Verulam. "Previous to the publication of the *Novum Organum,* natural philosophy, in any legitimate sense of the word, could hardly be said to exist." But "the immediate followers of Bacon and Galileo ransacked all nature for new and surprising facts, with something of that craving for the marvellous which might be regarded as a remnant of the age of alchemy and natural magic, but which, under proper regulation, is a most powerful and useful stimulus to experimental inquiry."[1]

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[1] Herschel's *Discourse,* pp. 105, 115.

Sir John Herschel, in his *Discourse on Natural Philosophy,* has taken up Bacon's pen, and advanced considerably in the line of his great master. In his chapters on the first stage of induction, the discovery of proximate causes, and laws of the lowest degree of generality and their verification; and on the higher degrees of inductive generalization, and of the formation and verification of theories; he has pushed forward the application of Baconian principles, and has thrown fresh light upon the true method of philosophical study.

How they have been employed in stimulating hope and effort appear, to go no further, in the following passages: "It requires a very extensive survey of the actual dominion of science, and a great sagacity, to judge, even in the loosest manner, what is beyond the possible limits of human knowledge." "We do not yet know the real nature of heat; but few would pronounce it impossible or unlikely that we may know it, in the same sense that we know other physical realities not immediately perceptible, before many years shall have expired."[1] Such language, by a distinguished historian of the progress of thought, is music set in a strain of which Bacon struck the key-note; and we are taught accordingly to despair of nothing reasonable, and to shrink from nothing possible.

Bacon's fame *increased as time rolled on.* "He was," says Bishop Spratt, "a man of strong, clear, powerful imagination. His genius was searching and invincible; and of this I need give no other proof than his style itself, which as for the most part it describes men's minds as well as pictures do their bodies, so it did his above all men living; the course of it vigorous and majestic; the wit bold and familiar; the comparisons fetched out of the way, and yet the most easy, in all expressing a soul equally skilled in men and nature."[1] Again, "When one considers the sound and enlarged views of this great man, the multitude of the objects to which his mind was turned, and the boldness of his style, which unites the most sublime images with the most rigorous precision, one is disposed to regard him as the greatest, the most universal, and the most eloquent of philosophers." Probably, traditions of his appearance, his manners, his eloquence, his wit, his genial qualities, added to his fame; for he could "assume the most differing characters, and speak the language proper to each, with a facility that was perfectly natural: or the dexterity of the habit concealed every appearance of art: a happy versatility of genius, which all men wish to arrive at, and one or two, once in an age, are seen to possess."[2] Finally, Addison remarks:[3] "His capacity seems to have grasped all that was revealed in books before his time; and, not satisfied with that, he began to strike out new tracks of science, too many to be travelled over by any one man in the compass of the longest life. These, therefore, he could only mark down, like imperfect coastings in maps, or supposed points of land, to be further discovered and ascertained by the industry of after ages who should proceed upon his notices or conjectures."

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[1] Hallam's *Int.*, iii. p. 200.

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[1] *History of the Royal Society.*

[2] Life prefixed to his Works. Ed. 1826, vol i. p. lix.

[3] *Spectator*, No. 554.

Now it is time to ask, What did Bacon think of religion and Christianity? With such extraordinary powers of mind, with such independence of judgment, with such vigilance against prejudice, what does he say on the second of the subjects to which this volume relates? In the first place, he had faith in God.

In his Essay on Atheism he remarks: "I had rather believe all the fables in the Legend, and the Talmud, and the Alcoran, than that this universal frame is without a mind; and, therefore, God never wrought miracles to convince atheism, because His ordinary works convince it. It is true that a little philosophy inclined man's mind to atheism; but depth in philosophy bringeth men's minds about to religion: for while the mind of man looketh upon second causes scattered, it may sometimes rest in them, and go no further; but when it beholdeth the chain of them confederate, and linked together, it must needs fly to Providence and Deity. Nay, even that school which is most accused of atheism doth most demonstrate religion; that is, the school of Leucippus, and Democritus, and Epicurus —for it is a thousand times more credible that four mutable elements and one immutable fifth essence, duly and eternally placed, need no God, than that an army of infinite small portions, or seeds unplaced, should have produced this order and beauty without a Divine marshal. The Scripture saith, 'The fool hath said in his heart, There is no God;' it is not said, 'The fool hath thought in his heart;' so as he rather saith it by rote to himself, as that he would have, than that he can thoroughly believe it, or be persuaded of it;

for none deny there is a God but those for whom it maketh that there were no God."[1]

Further, a religious spirit is blended with Bacon's philosophy. He had no sympathy with the Church of Rome in its treatment of Galileo; he had no narrow views of Scripture interpretation, which inclined him to mould his scientific conclusions in a corresponding form. He went to nature for his knowledge of nature, and to the Bible for his knowledge of religion; but in the former pursuit he sought the hallowing influence of the latter, believing that nature and the Bible had one infinitely wise and good Being for their author and their end. Hence the beautiful prayer with which he opens his *Instauratio Magna:* "We in the beginning of our work pour forth most humble and ardent prayers to God the Father, God the Word, and God the Spirit, that, mindful of the cares of man, and of his pilgrimage through this life, in which we wear out some few and evil days, Thou wouldst vouchsafe through our hands to endow the family of mankind with these new gifts; and we moreover humbly pray that human knowledge may not prejudice Divine truth, and that no incredulity or darkness in regard to the Divine mysteries may arise in our minds upon the disclosing of the ways of sense, and this greater kindling of our natural light; but rather that from a pure understanding, cleared of all fancies and vanity, yet no less submitted to, nay wholly prostrate before the Divine oracles, we may render unto faith the tribute due unto faith; and lastly, that being freed from the poison of knowledge infused into it by the serpent, and with which the human soul is swoln and puffed up, we may neither be too profoundly nor immoderately wise, but worship truth in charity." [1]

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[1] Essays, No. xvi.

Bacon's conduct as Lord Chancellor, however it may be extenuated on the ground of precedent, temptation, heedless extravagance, and the influence of servants, is an immense blot on his character; and the story of his fall, in consequence, is very sad. But it is gratifying to turn to the story of his last days. "The last five years of his life, being withdrawn from civil affairs, and from an active life, he employed wholly in contemplation and studies, a thing whereof his lordship would often speak during his active life, as if he affected to die in the shadow, and not in the light. During this time he composed, or revised and enlarged, the greatest part of his books and writings, both in English and Latin."[2] Still more gratifying is it to notice what we learn respecting his religious sentiments. He had professed a belief in Christianity when he was prosperous; in adversity he tested its value. In the pomp and pride of place he had not been ashamed of it; now, when he felt himself "a stricken deer," to the Gospel he turned for consolation.

We cannot help thinking that a remarkable prayer ascribed to him, in the 267th number of the *Tatler*, belongs to the closing period of his life. It contains a strange union of self-justification with humble confession. The former perhaps may be accounted for by that perverted feeling which he seems to have possessed about kind treatment which his servants and dependants had received at his hands. No doubt he had been charitable as a master and a friend, whilst he had been partial and unjust as a judge, corrupted by the gifts of suitors; but the former could never atone for the latter. The final part of the prayer however, is, very touching, and we see in it the inspiration of Christianity, which, as it produces a sense of sin, also binds up the broken-hearted penitent. "Most gracious Lord God, my merciful Father; from my youth up my Creator, my Redeemer, my Comforter. Thou, O Lord, soundest and searchest the depths and secrets of all hearts; Thou acknowledgest the upright of heart; Thou judgest the hypocrite; Thou ponderest men's thoughts and doings as in a balance; Thou measurest their intentions as with a line; vanity and crooked ways cannot be hid from Thee.

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[1] Works, vol. xiv. p. 11.

[2] Rawley Montague's *Life of Bacon*. Works, xvi. p. ccccxxi.

Remember, O Lord! how Thy servant hath walked before Thee; remember what I have first sought, and what hath been principal in my intentions. I have loved Thy assemblies, I have mourned for the divisions of Thy Church, I have delighted in the brightness of Thy sanctuary. This vine which Thy right hand hath planted in this nation, I have ever prayed unto Thee, that it might have the first and the latter rain, and that it might stretch her branches to the seas, and to the floods. The state and bread of the poor and oppressed have been precious in mine eyes; I have hated all cruelty and hardness of heart; I have (though in a despised weed)[1] procured the good of all men. If any have been my enemies, I thought not of them, neither hath the sun almost set upon my displeasure; but I have been as a dove, free from superfluity of maliciousness. Thy creatures have been my books, but Thy Scriptures much more. I have sought Thee in the courts, fields, and gardens; but I have found Thee in Thy temples.

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[1] Obsolete word for dress.

"Thousands have been my sins, and ten thousands my transgressions; but Thy sanctifications have remained with me, and my heart (through Thy grace) hath been an unquenched coal upon Thine altar.

"O Lord, my strength! I have since my youth met with Thee in all my ways, by Thy fatherly compassions, by Thy comfortable chastisements, and by Thy most visible providence. As Thy favours have increased upon me, so have Thy corrections; so as Thou hast been always near me, O Lord! And ever as my worldly blessings were exalted, so secret darts from Thee have pierced me; and when I have ascended before men, I have descended in humiliation before Thee. And now, when I thought most of peace and honour, Thy hand is heavy upon me, and hath humbled me, according to Thy former loving-kindness, keeping me still in Thy fatherly school, not as a bastard, but as a child. Just are Thy judgments upon me for my sins, which are more in number than the sands of the sea, but have no proportion to Thy mercies; for what are the sands of the sea? Earth, heavens, and all these are nothing to Thy mercies. Besides my innumerable sins, I confess before Thee, that I am debtor to Thee for the gracious talent of Thy gifts and graces, which I have neither put into a napkin, nor put it (as I ought) to exchangers, where it might have made best profit, but misspent it in things for which I was least fit. So I may truly say, my soul hath been a stranger in the course of my pilgrimage. Be merciful unto me, O Lord, for my Saviour's sake, and receive me unto Thy bosom, or guide me in Thy ways."

The story of Bacon's death has been already noticed. He caught a severe cold, in consequence of stuffing a fowl with snow, as an experiment with a view to its preservation. The incident occurred as he was riding in his coach on a winter's day between London and Highgate. He immediately became very ill, and was conveyed to the Earl of Arundel's house in the village. There he was put into a bed warm but damp, and there he expired on the 9th of April, 1626, in the sixty-sixth year of his age. The wish expressed in his will was complied with : "For my burial, I desire it may be in St. Michael's Church, near St. Alban's ; there was my mother buried, and it is the parish church of my mansion house of Gorhambury, and it is the only Christian church within the walls of old Verulam." [1]

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[1] Works, xvi. p. ccccxlvii. Selections from the works of Lord Bacon, with an introductory memoir, form one of the volumes published by the Religious Tract Society, under the general title of *Wisdom of our Fathers*.

It is unnecessary to refer to the charge of infidelity brought against Lord Bacon. That charge is examined and disposed of in Campbell's *Lives of the Chancellors*, iii. p. 142. Whatever might have been his opinions in early life, there can be no doubt of his sincere religious convictions afterwards.

RENÉ DESCARTES.

1596–1650.

Bacon and Descartes were contemporaries; and for some time the lustre of the first was surpassed by that of the second. Descartes stood at the head of European philosophers in the seventeenth century.

He was a Frenchman, born in 1596, of noble descent, and he possessed intellectual power united to a delicate physical constitution. In the neighbourhood of his father's residence, at La Flêche in Touraine, he studied at a Jesuit college; and at the age of thirteen won the title of "Young Philosopher." His early tastes are said to have been nurtured, if not inspired, by intimacy with a distinguished monk named Marsenne; but soon after attaining manhood, he appears as a soldier taking part in the wars which then desolated Europe. He fought in Holland under Maurice of Nassau; and in Germany under Maximilian of Bavaria. He passed into the service of the Emperor Ferdinand II.; and it is stated that he was at the siege of Rochelle in an attack on the English fleet. But in camp, as at college, he pursued his studies; and it is related that in Flanders he saw posted on a wall a geometrical challenge, according to the fashion of those times, and that the next day he sent a solution of the problem.

He afterwards travelled into Italy, and on his return determined to devote his life to philosophical inquiries. Selling a portion of his paternal estate, he left his native country for Holland, where he thought he could, with least interruption, follow the bent of his inclinations. When he became involved in controversy through his various writings, and had aroused the displeasure both of Roman Catholic priests and Protestant ministers by some of his speculations, he found Holland as well as France too hot for his residence; therefore he betook himself to Sweden, whither his fame had gone before, and accepted the protection and patronage of Queen Christina, who became his pupil, and took lessons of the philosopher at the hour of five in the morning. Early rising was not one of Descartes' virtues: and his efforts to overcome old habits, in a delicate state of health and in a rigorous climate, produced or increased pulmonary disease, which shortened his life, and he expired at Stockholm in 1650. His fame brought with it the penalty of numerous attacks on his opinions, and his early military encounters prefigured battles of another kind in which it was his lot to be engaged.

Descartes was a mathematician. He excelled in a science to which Bacon paid inadequate attention. There has been much dispute as to the originality of some of his views—for plagiarism is one of the offences of which he was accused, and it seems difficult to determine in many branches of learning what he borrowed and what was properly his own; but there can be no doubt that he wrought a great revolution in this department of abstract science. He is considered to have new-modelled the study of algebra, and to have totally superseded the geometry of the ancients. His conceptions of the properties of curve-lines and curve-surfaces, and his views of the constitution of equations, are spoken of as vast improvements, whether entirely original or not; and it is remarked by one who understands the subject, "Admitting, as we do, his claims on this head to be open to dispute, the writings and discoveries of Descartes have laid the foundation for such a change in the general character of mathematical science, as renders it extremely difficult for those who have not given very great attention to the older writers to follow the course of reasoning which they employed."[1]

Descartes devoted his mathematical genius to the study of optics. Here again we come across disputes as to the originality of his discoveries, and it is curious to find him pursuing an anti-Baconian method of investigation; instead of contenting himself with the results of experiment, he undertook to prove his conclusions by direct reasonings. In 1637 he announced in his *Dioptrics* that he had "solved the mystery of refraction." "He showed that the sine of the angle of incidence, at which the ray enters, has in the same medium a constant ratio to that of the angle at which it is refracted or bent in passing through." A "law of beautiful simplicity as well as extensive usefulness."[2] He also gave an explanation of the rainbow, so far as colour was not concerned, Newton being afterwards the first to solve that part of the problem. Descartes traced the path of the ray, and marked the angle of its incidence "with that which emerges after two refractions and one reflection."[1]

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[1] Knight's *Biographical Dictionary*, art. "Descartes."
[2] Hallam's *Introduction to Lit.*, iv. p. 49.

Descartes aimed at a new physical theory of the universe, and so far following in the track of predecessors, he indulged in empirical conjectures relative to the position and movements of the heavenly bodies, and adopted the idea of a vast ethereal fluid which was constantly revolving around a centre, like the dimpling eddies of a whirlpool. These were called *vortices*—utterly vain imaginations now exploded—but they did not appear so unsatisfactory and absurd in the seventeenth century as in the nineteenth.

"Descartes has left a treatise, highly valuable, but not very much known, on the art of logic, or rules for the conduct of the understanding. Once only, in a letter, he has alluded to the name of Bacon. There are perhaps a few passages in this short tract that remind us of the *Novum Organum*. But I do not know that the coincidence is such as to warrant a suspicion that he was indebted to it; we may reckon it rather a parallel, than a derivative logic; written in the same spirit of cautious, inductive procedure, less brilliant and original in its inventions, but of more general application than the *Novum Organum*, which is with some difficulty extended beyond the province of natural philosophy. Descartes is as averse as Bacon to syllogistic forms. 'Truth,' he says, 'often escapes from these fetters, in which those who employ them remain entangled. This is less frequently the case with those who make no use of logic, experience showing that the most subtle of sophisms cheat none but sophists themselves, not those who trust to their natural reason.' And to convince ourselves how little this syllogistic art serves towards the discovery of truth, we may remark that the logicians can form no syllogism with a true conclusion, unless they are already acquainted with the truth that the syllogism develops. Hence it follows that the vulgar logic is wholly useless to him who would discover truth for himself, though it may assist in explaining to others the truth he already knows, and that it would be better to transfer it as a science from philosophy to rhetoric."[1]

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[1] Playfair's Preliminary Dissertation to *Ency. Brit.*, p. 512.

Above all Descartes was a metaphysician; and in that capacity he mainly claims our attention.

Here first it should be remarked that he took the lead in studying the phenomena and the laws of the human intellect. If any man ever gave himself wholly up to the work of *introspection,* it was this philosopher. He turned his penetrating gaze inwards, and watched with intense curiosity and with immense patience the mysterious movements of his own consciousness. Thus he became what Dugald Stewart calls him, "the father of the experimental philosophy of the human mind."[2] In this department he proved himself an eminent experimentalist, and he gave a signal impulse to inquiries of this description; not that he excelled in recording numerous and important *facts* in this field of observation; but he formed a clear and precise conception of that operation of the understanding which Locke called reflection, and pointed out the subserviency of this power to satisfactory conclusions with respect to mental phenomena. Avoiding the use of *metaphors* in relation to points of consciousness, and also the habit of deducing inferences from material analogies, further studying in the clearest and simplest way what was going on in his own thoughts, he opened a new era in a most important division of philosophy.

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[1] Hallam, vol. iii. p. 259. "Règles pour la direction de l'esprit:" *Œuvres Complètes de Descartes*, Cousin, vol. xi. p. 255.
[2] First Dissertation in *Ency. Brit.*, p. 56.

Cartesian articles, now incorporated with accredited doctrines, include a luminous exposure of the logical error of attempting to define words which express notions too simple to admit of analysis; the exposure also of prejudices arising from a careless use of language; an assertion too of the paramount authority of the evidence of consciousness in all reasonings about the human mind; and the drawing of a clear distinction between the primary and secondary qualities of matter, —for example, between the qualities of extension and resistance on the one hand, and the qualities of colour and heat on the other. We now approach the most characteristic peculiarity of his teaching, and here cannot do better than use his own words respecting his peculiar habits of thought: "I was nourished with literature from my childhood; and since I was led to believe that by means of it one might acquire a distinct and assured knowledge of everything useful in life, I had an extreme desire to understand it. But no sooner had I completed that course of study, at the end of which a person is usually admitted into the rank of the 'learned,' than I entirely changed my opinion; for I found myself embarrassed with so many doubts and errors, that, as it seemed to me, no profit had been derived from my instruction except that I had discovered more and more my own ignorance. Nevertheless I was in one of the most celebrated schools in Europe, where I thought that there ought to be learned men, if there were any to be found on the earth. I had acquired all which others had acquired; indeed, not content with the sciences taught us, I had run through all the books treating of subjects curious and rare which had fallen into my hands. At the same time, I knew the judgment which others formed respecting me; and did not see that they regarded me as inferior to my fellow-students, though there were among them some destined to fill the places of our instructors. Lastly, the present age appeared to me as flourishing and as fertile in superior minds as any preceding one; and this made me take the liberty of judging others by myself, and of thinking that there existed no such learning in the world as I had been induced to hope."

After noticing other exercises which occupied attention in the schools, he proceeds to say of philosophy: "Seeing it had been cultivated by the most powerful intellects for many ages, and that nevertheless nothing could be found which some did not dispute, and therefore doubt, I had not presumption enough to hope I should fare better than others; and considering what divers opinions touching the same thing might be maintained by learned men, though it is impossible there should be more than one truth, I regarded as almost false everything only *probable*." "Hence," he goes on afterwards to tell us, "as soon as my years permitted me to escape from my preceptors, I quitted entirely the study of letters, and resolving to search after no other science than what might be found in my own self, or rather in the great book of the world, I spent the rest of my early life in travelling, in order to visit courts and camps, to mix with people of different humours and conditions, to collect varied experiences, to try myself in circumstances where fortune placed me, and throughout to make such reflection on what happened as might yield me some profit."[1]

We had a friend many years ago who endeavoured to escape from what he deemed the prejudices of education, and from all the bonds of human authority, by an effort to forget all which he had read on a particular subject, to make his mind as far as possible a *tabula rasa,* and to begin a fresh inquiry within a department of study of great importance, hoping thus to reach the purest and truest views of the matter in question. Descartes pursued a similar plan, and carried it out much more completely, with what result all the world knows, at least the scientific part of it.

"Among the various articles of common belief which Descartes proposed to subject to a severe scrutiny, he enumerates particularly—the conclusiveness of mathematical demonstration, the existence of God, the existence of the material world, and even the existence of his own body. The only thing that appeared to him certain and incontrovertible was his own existence; by which, he repeatedly reminds us, we are to understand merely the existence of his mind, abstracted from all consideration of the material organs connected with it. About every other proposition, he conceived that doubts might reasonably be entertained; but to suppose the non-existence of that which thinks, at the very moment it is conscious of thinking, appeared to him a contradiction in terms. From this single postulate, accordingly, he took his departure; resolved to admit nothing as a philosophical truth which could not be deduced from it by a chain of logical reasoning.

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[1] "Discours de la Méthode:" *Œuvres,* vol. i. pp. 125–131.

"Having first satisfied himself of his own existence, his next step was to inquire how far his perceptive and intellectual faculties were entitled to credit. For this purpose, he begins with offering a proof of the existence and attributes of God;—truths which he conceived to be necessarily involved in the idea he was able to form of a perfect, self-existent, and eternal Being."[1]

Two things strike us in the philosophy of Descartes which should be noticed before we proceed any further. The first is a strange combination of scepticism and belief. He begins by doubting. He will admit nothing whatever, within the whole range of knowledge, but the fact of his own consciousness. The heavens, the earth, mankind, the whole world, are to him unadmitted existences. His faith at the outset of his philosophy is confined to one little point, *himself*, and what is going on within his own mind. Of nought beside can he in any wise be sure. But he does not proceed far before we find that he is by no means what we understand by a thorough sceptic. So far from it, he has what we may call a wonderful appetency for belief. He as much hates unbelief as nature abhors a vacuum, and all his doubts are entertained for the simple purpose of securing in the end what he considers a firm and stable ground for a multitude of convictions. His doubts are provisional. They serve a purpose, and when they have accomplished it, faith begins to expatiate within a very wide circuit. As D'Alembert says, "Descartes began by doubting everything, and ended in believing that he had left nothing unexplained."

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[1] Preliminary Dissertation to *Ency. Brit.*, p. 59. Hallam gives a view of the metaphysics of Descartes in his *Introduction*, etc., vol. iii., extending from p. 229 to p. 268, with numerous references to Cousin's edition of Descartes' *Œuvres*.

Although Descartes may be regarded as a leader of modern thought, and may be believed to have laid the foundation of modern philosophy, there cannot be a greater mistake than to suppose that he was, in any true meaning of the term, the father of sceptical philosophy. After he starts from his first point, his career of philosophical thought is full of faith, without any allowance of doubts. What he was in point of fact differs altogether from what he is represented as having been in point of theory. He was a firm and steadily professed believer both in philosophy and religion.

The second obvious characteristic of his philosophy is the employment of the *deductive* as distinguished from the *inductive* method. Bacon delighted in experiments, hoping thereby to get at the secrets of nature. Descartes delighted in abstract reasoning, in following out inferences drawn from given premises; for he looked upon pure reason as the measure of all knowledge. Hence, even in the science of optics, where one might think experiment would content him, he must needs have recourse to abstract argument. There is a marked difference between mind and mind. The mental constitution of one man is strangely different from that of another; and hence we need a philosophy of *minds* in their manifold varieties, as well as a philosophy of *mind* in its essential properties and attributes. Some people have a natural turn for metaphysical reasoning, which manifests itself under circumstances unfavourable for its exercise. Without education, ignorant of the exercises of other minds, therefore perfectly unassisted in their lucubrations, they indicate a remarkable aptitude for abstruse and abstract argument. We remember once meeting with a common working man, who knew nothing of the doctrines of the schools, yet he could, after his own fashion, talk in a way which reminded us of the speculations of well-known philosophers. Of this peculiar idiosyncrasy Descartes was an illustrious example. He had no taste for the patient scrutiny of external facts. He was absorbed in the laws and consequences of human thought; and being impatient of what *is*, he was always asking after what *must* be.

His rank in the intellectual world is very high, and it is remarked by one who has boldly used the scalpel in the dissection of this philosopher's metaphysics: "The chief glory of Descartes consists not so much in the positive additions he made to human knowledge,—the fragments of truth which, tested by time, still remain undissolved amidst the ruins of his general system; nor even in his 'Method,' if we mean by that a system of rules for the prosecution of all science; but in the vast influence he exerted in the origination and development of modern philosophy, and indirectly on all its subsequent history; in the important degree in which he contributed to emancipate the human mind from the yoke of authority; in the effects of his method as applied to *one* branch of science, that of the mind, in which he justly earned the title conferred upon him by Stewart; and in the perpetual corrective reaction, supplied in the tendencies of his philosophy, to the excesses of the sensational schools. The enormous space he occupies in the annals of subsequent speculations may be estimated by the fact (almost literally true) stated by M. Cousin, that from the era of the publication of the *Meditations* (1637) to the end of the century, no philosophical work of any mark appeared that was not for Descartes or against him, or, at least, about him. Nor, lastly, amongst his merits must we forget tho beneficial influence he has exerted as a most robust thinker and a most admirable writer."[1]

As we turn to look at the theological opinions of this eminent thinker, we cannot help noticing again how very naturally many persons in the present day point with sympathy, if not triumph, to his negative beliefs. He, as we have seen, began by doubting, and continued to pursue truth, at any rate for a while, amidst an atmosphere laden with scepticism. But here we must repeat the remark, that he had no liking for disbelief and unbelief. Many forget that his first steps were simply provisional, that his ultimate object was not to destroy, but to construct. He is misunderstood now in another manner, perhaps, than that in which he was misunderstood when alive. Then orthodox thinkers accused him of atheism, because he widely deviated from their paths of procedure. This was cruelly unjust. Now thinkers not orthodox are apt to point with satisfaction and pride to one whom they esteem as having paved the way for their own conclusions. This proceeds on a thorough misapprehension. The fact is, that Descartes was as firm a believer in the fundamental truths of religion as any man ever was. No one could have a stronger faith in the existence of God, the immortality of the soul, and the dependence of all things on the Divine Being, than he had. His philosophy, in point of fact, never was a godless one. It placed a belief in the Divine Creator of all amongst the natural and indestructible convictions of the human mind. Whatever may be thought of his reasoning, and of the tendency of some of his speculations, the fact remains that he *was* a sincere believer in the truths of natural and revealed religion. He himself would have instinctively shrunk from the uses to which some of his methods have been put, and would have declined to accept certain professions of admiration which his works have inspired. He had no sympathy whatever with those who do not believe in God, who look upon the world as subject simply to impersonal and physical law, and who have no expectation of a life hereafter.

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[1] Rogers's *Essays*, i. p. 333.

But whilst Descartes held that the ends for which things were created is above our comprehension, and that his own reasoning on the subject of the Divine existence was all-sufficient, yet he regarded, and used as a stronghold, his innate conviction *that there is a God.* He put the matter thus: "When I turn my mind inwardly on myself, I not only apprehend myself to be incomplete, and dependent on another, and aspiring indefinitely after greater and better things, but at once I also perceive *Him* on whom I depend, to have all those things not only indefinitely, but infinitely, in Himself, and so to be God. The whole force of the argument is in Him, because I know it would not be possible for me to exist as I am, having in myself the idea of God, unless God really existed,—God, I say; He the same of whom the idea is in me; that is to say, of One having all those perfections which I am unable to comprehend, but which in some way I am able to touch in my thoughts, and who cannot be obnoxious to any defects. And from this it sufficiently appears that His existence cannot be a fallacy, for there can be no fraud, no deception in this natural light of humanity."[1] Arguments of a somewhat similar description are very ancient, and have been frequently adopted by minds of a certain order in modern times. The great metaphysician, Anselm, reasoned on the subject after a method of his own; and what he said found great favour with the schoolmen. The eminent Nonconformist philosopher and divine, John Howe, proceeded along a line of thought also resembling it in his book entitled *The Living Temple*;[2] and the renowned metaphysician, Dr. Samuel Clarke, adopted a like course, only dwelling more upon abstract ideas of space and time.[3] To many minds, perhaps the majority, such argumentation may appear destitute of force, and the inductive proof,—that based upon a survey of the works of creation,—will retain its popularity and effectiveness; but, looking at the different idiosyncrasies of people already referred to, there must be recognised a place for both modes of procedure by any one who takes a broad view of the facts of human nature. The one kind of argument by no means excludes the other. They are not at all antagonistic; they are mutually helpful, and combined they place the most fundamental of all religious convictions upon a sound and sufficient basis. And we may add that when we urge certain facts as implying the existence of a mind which controls, we do not pretend to say that they discover to us all that we should desire to know respecting God. If there be, as there is, a mystery beyond, we resort to other sources for light upon the subject; but our conviction of design, grounded on the facts, remains irremovable and irresistible; it is attached to the facts themselves. Descartes' famous axiom, "I think, therefore I am," comes in here. If I am something different from any machine, then so is design in nature different from the Designer; and we thus get the full force of the argument for the existence of God, which is as old as philosophy. We reach a principle which, on other grounds, Descartes held firmly and expressed clearly.

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[1] This occurs at the conclusion of his third Meditation. It will be found in the French translation: *Œuvres*, i. p. 290.

[2] See Howe's *Works*, published by the Religious Tract Society.

[3] See his *Demonstration*, etc.

"A spirit that impels
All thinking things, all objects of all thought,
And rolls through all things."—*Wordsworth.*

Mere science, as such, does not deal with the origin of things. This inquiry belongs to philosophy as distinguished from science. Science deals with the things themselves; and when the attempt is injudiciously made to control science by considerations drawn from supposed creative design, the attempt is resented, and the doctrine of final causes is brought into disrepute, especially when the proposed conclusions are based on part only of the phenomena to be examined. But the objection is irrational when the argument for design is attached to actual facts. We may, however, be hasty and ignorant in our interpretation; and patience is a virtue not only in morals, but in philosophy too.

Descartes zealously maintained the immateriality of the soul. The Jansenist Arnauld regarded what he wrote on this subject as most admirable. "What," he says, "you have written concerning the soul and body appears to me very clear, very evident, and quite Divine; and as nothing is older than truth, I have had singular pleasure to see that almost the same things have formerly been very perspicuously and agreeably handled by St. Augustine." But Descartes declined to employ the immateriality of the mind as a proof of its immortality. He contented himself with saying, that the dissolution of the union between soul and body could not of necessity deprive the former of existence, seeing they are essentially different; but the fact of continued existence, he thought, depended on the will of God, and His determination in reference to it could only be learned from Divine revelation.[1] In that revelation he firmly believed, and had no doubt as to the immortality of the human soul.

His notions of free will were very pronounced; but here again we have pious conclusions associated with a doctrine which many would cut off from all such alliance. "As to free will," he remarks, "I own that thinking only of ourselves we cannot but reckon it independent; but when we think of the infinite power of God we cannot but believe that all things depend on Him, and that consequently our free will must do so too." "But since our knowledge of the existence of God should not hinder us from being assured of our free will, because we feel and are conscious of it in ourselves, so that of our free will should not make us doubt of the existence of God. For the independence which we experience and feel in ourselves, and which is sufficient to make our actions praiseworthy or blameable, is not incompatible with a dependence of another nature, according to which all things are subject to God."[1] These sentiments are couched in a spirit of devout piety; and an inspiration of the like character has been caught from his writings by eminent Christians of different Churches. John Smith, of Cambridge, was much influenced by the Cartesian philosophy, on its religious as well as its metaphysical side; and Malebranche, who saw God in all things, and all things in God, was one of Descartes' most distinguished disciples.

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[1] *Œuvres*, ix. p. 369.

In conclusion, on comparing Bacon and his French contemporary, we see two philosophers of very different habits of thought maintaining the same religious doctrines on divers yet not inharmonious grounds. As in philosophy so in religion, there is room for induction and deduction; and these daughters of human wisdom, united in a sisterhood truly Divine, may both be helpful to earnest students, seeking for truth, for God, and for eternal life, through Jesus Christ our Lord.

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[1] *Œuvres*, ix. p. 368. Translated in Hallam, *Int.* iii. pp. 262–3.

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BLAISE PASCAL.

1623–1662.

He was born on the 19th of June, 1623, at Clermont Ferrand, in Lower Auvergne, under the shadow of the lofty Puy-de-Dôme, which crowns the group of mountains in that volcanic district. Bacon had recently published his *Novum Organum,* and was nearly at the end of his earthly course, and Descartes had just commenced his philosophical career, when this extraordinary genius entered the world, to occupy a place of renown scarcely second to either. It is interesting to remember that at the same time Cardinal Richelieu, as prime minister to Louis XIII., controlled the government of France; and the Thirty Years' War was spreading havoc and desolation all over Germany. Pascal's father was a man of good family, and to the distinction of rank added official ability, intellectual power, and educational attainments, all of which proved advantageous to his son. When they removed to Paris, in 1630, the beauty and talent of the boy, as well as the character of the parent, attracted the notice of the cardinal, who said he would like to make something great of him. The lad's precocity excited the wonder of relatives and friends; and it is said of him, that when others spoke of reasons, he tried to discover them for himself, and never gave up a subject until he had penetrated to the bottom of it.

At an early period misfortunes befel the family. Pascal's father incurred the anger of Richelieu, and for some time had to conceal himself; but through the ingenuity of a charming daughter forgiveness was obtained and favour was restored, in consequence of which the cardinal appointed him Governor of Rouen, whither he repaired with his children to take up their permanent residence in that city. Thus it became associated with one of the most illustrious Frenchmen that ever lived; and the studies which he there pursued with amazing ardour so undermined his constitution that he never recovered from the effect. From the age of eighteen he was scarcely ever free from pain; yet in intervals of comparative ease he renewed his philosophical inquiry with undiminished earnestness. Nervousness, headache, and acute internal pain tormented the youth; and his niece informs us that for a time he became paralysed from the waist downwards, his feet being cold as marble, so that he had to wear socks soaked in brandy.

In January, 1646, his father, who had been greatly injured by an accident, sought assistance in his official duties from two Norman gentlemen who had embraced the opinions of Jansenius, Bishop of Yprès, then advocated by the distinguished fraternity known as Port Royalists. Conversation turned much on the subject, and Pascal's sister Jacqueline soon became a convert. She went to Paris, and her brother went too, partly from sympathy in her sentiments, partly to seek medical relief from his suffering. In 1648 the father also went to reside in Paris, and died there in 1651.[1] After his death we find the son continuing his residence in the royal city, associating much with the Duc de Roannes, living amidst fashionable society, and indulging, it would seem, in extravagant habits. The upper classes in Paris were at that time mad about the mysterious and senseless quarrels of the Fronde, and mingled with their party politics all kinds of dissipation. The hotels of the nobility were scenes of dissoluteness, and that of the Duke, Pascal's friend, resembled the rest, nor can there be any doubt that he witnessed a great deal of immorality; but it has been remarked by one of his admiring editors, Faugère, with that felicity of diction peculiar to the French, that if his feet for a moment touched the mire, his divine wings continued to be unsoiled. In 1654, as he was riding across the bridge of Neuilly in a carriage, the vehicle was on the edge of a precipice; the two leaders fell over and were killed, Pascal's life was saved by the breaking of the traces; but the shock to his nervous system was so great that he never overcame it, and from that time he changed his manner of life, and separating himself from worldly society, devoted his thoughts to the truths and duties of religion.

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[1] There is a long and interesting letter by Pascal on his father's death in *Œuvres Complètes de B. Pascal*, tome ii. p. 20.

Port Royal des Champs is a world-known spot in the neighbourhood of Paris, seven or eight miles from Versailles. A rude enclosure marked by a cross, amidst perfect seclusion, indicates where the monastery once stood, so illustrious in French history on account of the gifted names connected with it. Portraits of Pascal and his sister, of the Arnaulds, of De Sacy, the eminent translator of the Scriptures, of the Mère Angélique, and the Mère Agnes, are still preserved in the place, as mementoes of a society which has filled France and the world with the echo of its fame. La Mère Angélique, the abbess, was of the Arnauld family, a family alike distinguished by intellectual powers and devout affections; and with the Arnaulds Blaise Pascal was on terms of intimate friendship.

Port Royal had a brotherhood as well as a sisterhood; and with the former, occupying an abode called Les Granges, Pascal to some extent united himself in 1655. They did not, like regular monastic orders, assume any distinctive dress, but only lived in great simplicity, spending the day in acts of devotion, beneficence and industry. When they met in chapel after private prayer at early morn, they kissed the earth as a sign of lowliness; they dined together, when lives of the saints were read to them. Morning and afternoon they worked in the fields; and from three in the morning till the hour of rest at night, they had the usual religious services of a monastic life; confession, communion, fasting and austerity, were observed and maintained by these pious recluses. It is not clear how far Pascal identified himself with the community. He did not permanently take up his abode with them, but only at intervals paid them a visit, so that he went so far as to say "he did not belong to Port Royal." Pascal seems, however, to have enjoyed the habits to which he was now addicted, and says that at Port Royal he was treated like a prince: indeed, his health improved, and his sister says he was "gay in his solitude." The miracle of the Holy Thorn, as it was called—that is to say, the recovery from sickness of one of the sisterhood after touching a relic brought to the abbey—occasioned much controversy, which Pascal took up with great ardour, defending his view of the circumstance as a Divine interposition. "He was sensibly touched by such a grace, regarding it as virtually done to himself, seeing it was done to one so near to him in kindred, and who was his spiritual daughter in baptism." The lady in question was Marguerite Périer, Pascal's niece.

In 1656 "the religious world" in France was agitated by a controversy between the Jansenists, who, following Jansenius, adopted what they held to be the opinions of St. Augustine on the doctrine of Divine grace; and the Jesuits, a well-known ecclesiastical order, which, on that subject, entertained a different opinion, leaning, it was thought by their opponents, in the direction of Pelagianism. Disputes about the contents of a certain book written by Jansenius, the *Augustinus,* became mixed up with disputes about the doctrine itself, and an enormous amount of personal and party feeling arose between the Jesuits and the Jansenists. The Dominican order also became involved, because their theological sentiments were regarded by the Jansenists as in sympathy with their own; but the Jesuits claimed them as allies on the side of the Papal Church, a claim to which the Dominicans were ready to respond. Papal bulls and other influences served to increase the controversial fires, and a good many fingers were burnt by intermeddling with the flame. Pascal, who agreed with the Jansenists and disliked the Jesuits, began to publish anonymously, in 1656, his famous *Provincial Letters,* in which he skilfully exposed the sophisms and intrigues of the latter fraternity, and held them up to ridicule and scorn. The effect was wonderful, and those who know anything of Parisian society at the time,—of the controversial atmosphere of the University of the Sorbonne, of the part played in France by the Jesuits, of the religious sympathy felt by many in reference to the Jansenists, and the keen appreciation of wit and humour by the Gallic intellect,—will easily understand how the *Provincial Letters* became most popular, and afforded a subject for brilliant conversation in the salons of the literary and the fashionable.

Soon after the great intellectual effort thus made by Blaise Pascal, physical suffering returned with increased intensity, and this again was further deepened by the religious austerities which he practised with merciless self-denial. Yet all this failed to extinguish his mental energies, and in 1658 we find him, when tormented by a paroxysm of toothache, turning once more to his favourite mathematical pursuits.

He revolved in his mind problems touching the cycloid—to be noticed presently—and having reached certain results, it was arranged that they should be tested in a curious way: prizes were offered for a solution of questions, carefully defined, but the plan proved quite unsatisfactory, and soon afterwards, in consequence of his infirmities, the philosopher relinquished the studies in which he had attained such distinguished eminence.

Pascal is pronounced by Bayle to have been one of the sublimest geniuses of the world—high praise indeed from the pen of so sceptical a critic, but not more than has been conceded by a crowd of admiring commentators ever since. Pascal's genius was not that of a poet, though some have ascribed to him a poetic faculty. It would be quite out of place to associate him with Shakespeare and Milton, though he has been coupled with those illustrious men. Socrates, Plato, and Bacon are names to which that of Pascal may be more appropriately attached; as, like them, he possessed in the highest degree what we generally understand by the word *wisdom.* Profound views of human nature, a keen power of analysis, a faculty of comprehension which commanded a wide survey both of resemblances and differences, rarely combined in the intellectual visions of even accomplished and catholic thinkers, and a penetrating insight into fundamental principles and facts underlying superficial phenomena,—these were characteristics of Pascal's mind, and raised him to the highest rank in human intelligence. His *Pensées* form the mirror in which we see reflected the peculiar movements of his extraordinary intellect. They were not published until he had left the world. They had been written or jotted down at intervals upon scraps of paper, without consecutive order, and were found in confusion after his decease, like the scattered leaves of the Sibyl. No doubt they were related to each other, and could have been harmoniously adjusted and systematized by their author; but as it is, the reduction of them into a connected form must remain an utter impossibility. However, there is after all something in the circumstances of their appearance which throws light on Pascal's thoughts. He did not addict himself to trains of reasoning. He was not fond of scholastic methods of argument and terminology. Logical concatenations had no charms for him. Intuitive perception was his great power: clear gazings upon truth, rather than glimpses and guesses, were at once his achievement and his delight. His *Thoughts* are a collection of aphorisms or oracles, often remind-ing us of the rich veins of reflection running through Bacon's essays. They require to be studied, to be pondered, to be revolved, to be examined again and again, in order that their depths may be fathomed, their breadths compassed, and their importance weighed. There is no book more fit to be a *vade mecum,* a companion in solitude, a friend in silent hours. No pages are more apt to invite pencil-marks, to receive scoring lines under key words, and interpretative phrases. And in the treatment of human life, human reason, and human character, we see much of the author's idiosyncrasy. We miss what is genial and kindly. His views are sombre, sad, melancholy. There is little of sunlight, there is much of cloud and shadow. But the stream of his wisdom is always full and clear and rich.

"Let man contemplate the whole of nature in its sublimity and majesty—the glorious luminary which hangs as an everlasting lamp to illumine the universe; and the earth which is a mere point in the immensity of space; and labour as he may to conceive of these distances, they will be but atoms compared with the reality. It is an infinite sphere whose centre is everywhere and its circumference nowhere."

"The Stoics say, 'Retreat within yourselves, and there you will find rest;' but that is not true. Others will tell you to go forth abroad and seek happiness in diversion; neither is that true: happiness is neither within nor without. It is in God, and our union with Him."

"The nature of man may be regarded in two ways: according to his end, then is he grand and incomparable; and according to his passing pursuits, as we judge of the habits of a horse or a dog, then man is abject and vile. Behold the reason why philosophers judge so differently; one denies what the other admits. The first says he is born for no such end, all his actions are repugnant to it; the other says he deviates from that end when he performs ignoble acts."[1]

Pascal's wisdom is almost equalled by his wit. Voltaire said that Molière's best comedies do not excel them—*i.e.* the *Provincial Letters*—in wit, nor the compositions of Bossuet in sublimity; and D'Alembert remarks, "This work is so much the more admirable, as Pascal in composing it seems to have theologized two things which seem not made for the theology of that time, language and pleasantry." As we read these eulogies, after that by Bayle, we are struck with the singular power which Pascal possessed of inspiring the deepest admiration in men destitute of religion. Certainly the *Lettres Provinciales* overflow with wit from end to end. Whilst the language sparkles with that quality, golden ingots of it lie hidden in the substance and illustrations. Well might a contemporary correspondent write to his friend, on receiving one of the famous letters, "You can have no idea how much I am obliged to you for the letter you sent me, it is so very ingenious and so nicely written. It narrates without narrating. It clears up the most intricate matters possible; its raillery is exquisite; it enlightens those who know little of the subject, and imparts double delight to those who understand it. It is an admirable apology; and if they [the Jesuits] would take it, a delicate and innocent censure. In short, the letter displays so much art, so much spirit, and so much judgment that I burn with curiosity to know who wrote it."[1]

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[1] Slightly abridged, *Pensées : Œuvres Complètes de B. Pascal* (Edit. 1877), i. pp. 246, 250. Editions vary. In some it is Article i. pp. 9, 10.

Wisdom and wit are often regarded as alien powers, but certainly they live in harmonious society on the pages of Pascal, nor is their agreeable alliance by any means so strange as some suppose.[2]

His style of composition is as felicitous as his thoughts are bright and rich and fruitful. By the confession of the first French critics, the *Lettres Provinciales* did more than any other composition to fix the French language. On this point the suffrages of all the most competent judges, of Voltaire and Bossuet, D'Alembert and Condorcet, are unanimous. "Not a single word occurs," says the first, "partaking of that vicissitude to which living languages are so subject. Here then we may fix the epoch when our language may be said to have assumed a settled form." "The French language," says D'Alembert, "was very far from being formed, as we may judge by the greater part of the works published at that time, and of which it is impossible to endure the reading. In the *Provincial Letters* there is not a single word that has become obsolete; and that book, though written above a century ago, seems as if it had been written yesterday." The French language at that period was far behind our own. No standard authors, like those of the Elizabethan period, had been seen on the other side of the Channel; and Pascal did for France what no one has ever done for England. A succession of writers from Shakespeare to Dryden, and particularly the English version of the Scriptures, fixed our written tongue; and therefore no adequate parallel can be found in our literary history to the epoch fixed in France by the illustrious Port Royalist; but the parallel wanting here exists in Germany, where Martin Luther is universally acknowledged to have stamped the mark of his genius on the speech of his countrymen; and it is worthy of note that in the two most intellectual nations of Europe the language of the people has received an indelible impress from theological authors.

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[1] Quoted in Tulloch's *Pascal*, p. 130 (Foreign Classics: Blackwood), the best popular sketch in our language of the author of the *Pensées*.

[2] See on this subject the Essay on Pascal in Rogers's *Essays*, i. p. 230.

Pascal was a born mathematician. Geometry came to him by a sort of inspiration. Simply told by his father, who wished at the time to discourage his desire "for that kind of study," that mathematics consisted in finding out the relations and properties of figures, he set to work with a piece of charcoal and marked on the floor an equilateral triangle. He then invented names, definitions, and axioms, and finally demonstrated, without any instruction, what amounted to the thirty-second proposition of the first book of Euclid, namely, that the exterior angle of a triangle is equal to the two interior and opposite angles, and the three interior angles are together equal to two right angles. Before he had reached his seventeenth year he wrote a treatise on conic sections which filled Descartes with incredulity and astonishment. And as the first stroke of Pascal's genius was mathematical, so was the last —the study of the cycloid or trochoid, *i.e.* the line described by the motion of a point in the circumference of a wheel, as it makes its revolution. Torricelli had worked at the problem with success; but Pascal carried his solution further, and discovered the length of the cycloid and its centre of gravity; in fact, in these researches he approximated to the differential and integral calculus which was reached by Leibnitz and Newton. After a competition for the prize, in the way described, had ended in comparative failure,—Lallouère the Jesuit and Wallis our fellow-countryman not discovering (it was said) a method which complied with the prescribed conditions,—Pascal published his own treatise on the subject, which Wallis described in a letter to Huyghens as a work of great genius. Other mathematical treatises were composed by our author: the *Traité du Triangle Arithmétique*, and the *Tractatus de Numericis Ordinibus*. "By means of the Arithmetical Triangle," says Sir David Brewster, "an invention equally ingenious and original, he succeeded in solving a number of theorems which it would have been difficult to demonstrate in any other way, and in finding the coefficients of different terms of a binomial raised to an even and positive power. The same principles enabled him to lay the foundation of the doctrine of probabilities, an important branch of mathematical science, which Huygens a few years afterwards improved, and which the Marquis La Place and M. Poisson have so greatly extended."[1]

With a genius for mathematics, Pascal was master of a faculty for observation. In this respect he manifested a singular precocity. Observing when a child that a plate lying on the table emitted a sound as soon as it was struck, which sound ceased as soon as a hand touched the plate, he began to reason on the nature of sounds, and, though only twelve years of age, proceeded to write an essay on the subject. These early efforts of curiosity were a prelude to results in after years of the greatest importance. One of these related to the weight of the atmosphere. It had been ascertained that water in a pump could not be raised beyond thirty-two feet above the surface. Why? Galileo attributed the fact to nature's abhorrence of a vacuum, and said, oddly enough, that the abhorrence extended to that degree, and no further. Torricelli took up the problem, convinced that the weight of water had to do with the phenomenon, and by experiment came to the conclusion that the weight of the atmosphere was the counterbalancing force. Pascal took up the matter where Torricelli left it, and showed that if we alter the length of the superincumbent column of air by going to a high place, we alter the weight which it will support. Pascal, with all his feebleness, mounted a church steeple in Paris, and with a column of mercury in a Torricellian tube, compared the weights of the air at the top and the bottom. A still more decisive experiment he proposed and carried out, by means of his brother-in-law, on the summit of the Puy-de-Dôme, in Auvergne, the old home of the Pascals. "You see," he wrote to him, "that if it happen that the height of the mercury at the top of the hill be less than at the bottom (which I have many reasons to believe, though all those who have thought about it are of a different opinion), it will follow that the weight and pressure of the air are the sole cause of this suspension, and not the horror of a vacuum; since it is very certain that there is more air to weigh on it at the bottom than at the top; while we cannot say that nature abhors a vacuum at the foot of a mountain more than on its summit." The brother-in-law made the experiment, and found a difference of three inches in the mercury on the top of the mountain compared with the height of the mercury at the bottom, which he says, "ravished us with admiration and astonishment."[1] In the autumn of 1647, Descartes had paid Pascal a visit in Paris, and conversed on the subject of a new barometer.[2] The announcement of Pascal's discovery led to an unpleasantness with the philosopher Descartes, who claimed the credit of having suggested the experiment to Pascal. This kind of conflict is not uncommon amongst scientific men. Coincidence of independent thought, rather than plagiarism, is often the cause of two or more persons reaching the same result; and in this case there seems no room for doubt that, though Descartes had an idea similar to Pascal's, and probably mentioned it to him, the latter was conscious of the originality of his own conception. Descartes was much more likely to be jealous of Pascal, than Pascal was likely to be an unacknowledging borrower of Descartes.

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[1] *North Brit. Rev.* August, 1844.

Pascal was an inventor as well as a discoverer. He invented a calculating machine, and thus he appears as the precursor of Babbage. The *Encyclopédie*[3] gives a description of this curious instrument, according to the idea of the inventor, which, however, it was found extremely difficult to embody and execute in its mechanical details. Hence Pascal obtained, in 1649, a royal patent for the invention, to be executed by workmen in his own employ. But it proved of no practical use, whether because of its imperfect construction or not seems undetermined. It is easy, in cases of failure, to throw the blame on the mechanical working out of the idea rather than on the idea itself. "It is said that Mr. Babbage's machine, much more his marvellous analytic engine, have never yet been properly constructed."[1]

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[1] Whewell's *Inductive Sciences*, ii. p. 53.

[2] See lively letter of Jacqueline, dated September 25, 1647. *Jacqueline Pascal.* Par Victor Cousin, p. 114. The difficulty of these philosophers is curiously characteristic of scientific questions at the time: "What was in when the air was out?"

[3] The article is inserted in *Œuvres Complètes de B. Pascal*, iii. pp. 185–208, together with Pascal's letters on the subject.

Another invention by Pascal was what perhaps few would anticipate, though almost everybody now-a-days avails himself of it. It was an omnibus. "Carrosses à cinq sols" were running in the streets of Paris in 1662; and the privilege of providing these convenient vehicles was, by royal patent, conferred on the Duc de Roannes, Pascal's friend. The idea is commonly ascribed to Pascal himself, and there is no reason to doubt that it was really his. It would seem amusing, but it would not, after all, be incongruous for a passenger to take out of his pocket the *Thoughts* or the *Letters* of Pascal, and read them in an omnibus.

Pascal at an early period resisted the efforts of those who would lead him into paths of unbelief. He derived from his father a great respect for religion, and looked upon the freethinkers who came in his way as men who had adopted the false principle that human reason is superior to all things, and who do not understand the nature of faith. Pascal's sister tells us this, and adds that "his spirit, so comprehensive and inquisitive, which searched with so much care into the cause and reason of everything, was at the same time, in reference to religion, as a child; and this simplicity reigned in him throughout his whole life."[1] His first conversion, as it is sometimes called, occurred before he was twenty-four years old, through a course of reading, which made him feel that Christianity requires us to live for God, and to have no other object than His glory. So overpowering was this conviction, that for a while it led him to suspend his scientific studies. At this time he fell into some extravagances of theological opinion, and ever afterwards entertained notions of self-denial which were unreasonable and unwarranted by Scripture, but sanctioned by the doctrine and discipline of the Romish Church, in which he had been brought up, and to which he remained faithful until the end of life. After a course of worldliness, he returned to a more earnestly religious life than he had ever spent before. This was when he joined the Port Royalists; and this has been termed his second conversion. This change took place in 1655, when he was about thirty-two. The accident which had happened a few months before, and which had brought him so near the abyss of eternity, served, no doubt, to deepen and perpetuate his pious convictions.

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[1] Tulloch's *Pascal*, p. 28.

He did not approach religion by a mere logical process, but through sentiments of the heart. Such an approach harmonized with philosophical views which led him to regard mankind not merely as intellectual beings, made only or chiefly to argue and reason, but as creatures of emotion and sentiment, very much under the influence of feeling by the original constitution of their nature, and therefore, in moral and spiritual questions, such as Christianity brings before the mind, made to be swayed by pure and exalted impulses rather than by the dry light of an independent intellect. He could not look on religion as simply matter for reasoning. It appealed, he said, to the heart; it was meant for the heart, and only in the depths of the heart could it find its full response. His philosophy of human nature prepared him for his philosophy of religion. He dwelt much on the vanity of man, the weakness of man, and the misery of man. Sometimes he used expressions onesided and extravagant; his expositions of moral problems are not always as satisfactory as his expositions of mathematical ones; yet who is there that can resist the truth and force of certain aphorisms in his *Thoughts*, which have become commonplaces in our religious literature: "The greatness of man is seen in this, that he knows himself to be miserable. A tree does not know itself to be miserable. It is misery indeed to know oneself miserable; but there is greatness in it also. A man's miseries go to prove his greatness. They are the miseries of a mighty potentate, the miseries of a dethroned monarch." "Man is a reed, the feeblest thing in nature; but it is a reed holding in itself the power of thought. It needs not the universe to be armed for its destruction; for that a breath, a drop of water, suffices. But were the whole universe to rise up against him, man would be more noble than his enemy, for he knows that he dies. And this advantage he has over the universe, for the universe knows nothing. All our dignity consists in thought."[1] No man ever saw more clearly the contrarieties of humanity, its capacities on both sides,—of sublimity, of exaltation, on the one side, of degradation and meanness on the other. He felt conscious of the original beauty of the spiritual nature of man, and of the defacement of that beauty, to a large extent, as the effect of sin. Sin he did not regard as a disease or accident, but as a terrible creation of the human will, bringing with it guilt and misery. He turned to the fall of man, taught by the Bible, as the best explanation of the present condition of humanity. That condition he recognised as demonstrative of the necessity of religion for man's restoration and happiness. Without it, he must pine and perish; with it, he can rise to moral greatness and immortal bliss.

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[1] *Vie de B. Pascal.* Par Mme. Périer, prefixed to *Œuvres Complètes*, i. p. 5. This life, by his sister, is the chief authority for the facts related in this sketch.

Pascal did not dwell upon the tokens of intelligent design in the universe as proofs of the existence of God. For that line of argument he had a distaste from the very make of his mind; and he also differed from Descartes, in not using metaphysical arguments in proof of the Divine existence. Descartes, he said, attempted the impossible. Pascal based his belief in a moral Governor of the universe upon moral considerations and the sentiments of the heart. When his intellect drove him into straits on this subject, he was prepared as a last resource to fall back upon the practical idea, "If you win, you win everything; if you lose, you lose nothing. Wager, then, without hesitation, that God exists. On one side is an eternity of life of infinite blessedness to be gained; and what you stake is finite. Our proposition is, that the finite is to be vested in a wager, in which there is an equal chance of gain or loss, and infinitude to gain." This style of thought, according to Bayle, is derived from Arnobius, one of the Christian fathers, who argued that those who believe in a God may be eternally happy if they be in the right, and that they lose nothing if they are mistaken; but an atheist gains nothing if he be in the right, and renders himself eternally miserable if he be in the wrong.[1] It is easy to criticise this method of raising and determining so momentous an issue. Looking at the matter in a dry intellectual atmosphere, such a mode of mental treatment, in relation to the Divine existence, will appear unsatisfactory and even absurd. Yet, looking at it practically, and with the whole heart, we must needs confess *there is something in it.* At all events, the craving after God, thus made manifest, can never be quenched by any so-called scientific reasoning; and the hearts of millions, including many a philosopher, as well as many a peasant, still beat at the cry uttered thousands of years ago by the patriarch Job, "Oh that I knew where I might find Him!"

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[1] *Œuvres Complètes de Blaise Pascal*, i. pp. 248, 249. *Pensées*, article premier.

As with natural, so with revealed religion, Pascal rested on moral and internal, rather than external and historical proofs, though the latter, in a certain form, were included within the range of his reflections on the subject. This will appear in the following analysis of Pascal's argument in the *Pensées,* as presented by Vinet: "It is impossible to look at all the proofs of the Christian religion collected together without feeling their force, which no reasonable man can resist. Let any one think of its establishment,—that a religion so contrary to nature should have been established of itself, so peacefully, without any force or constraint, and yet so powerfully that no tortures could deter the martyrs from confessing it; and that all this should have been done, not only without the aid of any prince, but in spite of all the princes of the earth who opposed it.

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[1] Bayle's *Dictionary*, art. "Pascal."

"Let any one consider the holiness, the loftiness, and the humility of a Christian soul. The heathen philosophers sometimes raised themselves above the rest of mankind by a better-regulated manner of living, and by sentiments which had some conformity with those of Christianity. But they never recognised as a virtue what the Christians call humility, and they would even have regarded it as incompatible with other virtues of which they boasted. It is only the Christian religion that has known how to join together things that till then had appeared so opposite, and has taught men that, so far from humility being incompatible with the other virtues, without it all the other virtues are but vices and defects.

"Let any one consider the marvels of the Holy Scripture, which are infinite, the grandeur and the superhuman sublimity of the things which it contains, and the admirable simplicity of its style, which has no affectation, no pretension, and which bears a stamp of truth which cannot be gainsaid.

"Let any one consider the character of Jesus Christ in particular. Whatever sentiment we may have of Him, it cannot be doubted that He had a very great and a very lofty mind, of which He gave indications from His childhood in the presence of the doctors of the law. And yet, instead of applying Himself to the cultivation of His talents by study, and by associating with the learned, He passes thirty years of His life in manual labour, and in entire seclusion from the world; and during the three years of His preaching He calls to His company and chooses for His apostles men without knowledge, without study, without reputation; and He draws upon Himself the enmity of those who were reputed the most learned and the wisest men of their time. A strange procedure for a man whose design is to establish a new religion!

"Let any one consider attentively those apostles chosen by Jesus Christ, those illiterate men, without study, who yet are found all at once sufficiently learned to confound the most skilful philosophers, and sufficiently strong to resist kings and tyrants who opposed themselves to the establishment of the Christian religion which they announced.

"Let any one consider that marvellous succession of prophets, who succeeded one another during two thousand years, and who all predicted, in so many different ways, even the minutest circumstances of the life of Jesus Christ, of His death, of His resurrection, of the mission of the apostles, of the preaching of the gospel, of the conversion of the nations, and many other things which relate to the establishment of the Christian religion, and the abolition of Judaism.

"Let any one consider the wonderful accomplishment of these prophecies, which meet so perfectly in the person of Jesus Christ that it is impossible, without wilful blindness, not to recognise Him.

"Let any one consider the state of the Jewish people, both before and since the advent of Jesus Christ; their flourishing condition before His coming, and their miserable state since their rejection of Him; for they are to this day without any sign of religion, without a temple, without sacrifices, scattered over all the earth, the scorn and the offscouring of all nations.

"Let any one consider the perpetuity of the Christian religion, which has always subsisted since the beginning of the world, whether among the saints of the Old Testament, who lived in the expectation of Jesus Christ before His advent, or among those who have received Him and believed in Him since His coming; whereas no other religion has perpetuity, which is the chief characteristic of the true.

"Lastly, let any one consider the holiness of this religion, its doctrine, which explains even all the contradictions which meet in man; and all the other singular, supernatural, and Divine things, which shine out on all sides of it.

"And let any one judge, after all this, whether it be possible to doubt that the Christian religion is the only true religion, and whether any other have ever approached to it."[1]

The personal reliance of Pascal for acceptance by God rested in Christ alone: "I stretch out my hands to my Liberator, who, having been foretold during four thousand years, came to suffer and to die for me upon the earth, at the time and under the circumstances foretold; by His grace I await death in peace, in the hope of being united to Him for ever."[1] And in like manner he confided in the sanctifying work of the Holy Spirit, for his prayer is: "Fill me, O Lord, with Thyself, and with Thy Holy Spirit!"[2]

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[1] Vinet's *Studies on Pascal* (Edin. 1859), p. 49. The heads of the evidence may be found in *Œuvres Complètes,* i. p. 312. The *Pensées* are differently arranged in different editions. On the plan of the *Pensées,* see Vinet, pp. 53–85.

Pascal has been charged with philosophical scepticism. Of his religious sincerity there can be no doubt. Throughout his life he professed Christianity, and in his latter days demonstrated the effect it had upon his will, his character, his whole being. Yet M. Cousin would make us believe that, as a philosopher, he lived all the while in an atmosphere of doubt. This is passing strange, when we find Pascal protesting against Pyrrhonism.

"We discover truth," he says, "not only by reasoning, but by feeling (*le cœur*); and it is in this latter manner that we discover first principles; and in vain does reasoning, which has no share in their production, try to combat these principles. The Pyrrhonists, who attempt this, labour in vain. We know that we are not deceived, however incapable we may be of proving so by any power of reasoning. This incapacity only demonstrates the weakness of our reasoning faculty, and not the incertitude of all our knowledge, as they pretend. Nay, our knowledge of first principles, such as the ideas of space, time, motion, number, is as certain as any obtained by reasoning. It is, in fact, upon such conclusions of feeling and instinct that reason must ultimately rest and base all its arguments. We feel that there are three dimensions in space, and that numbers are infinite; and reason hence demonstrates that there are no two square numbers the one of which is double the other. Principles are felt, propositions deduced, and both with certitude, although in different ways. And it is as absurd for the 'reason' to demand of the 'heart' proofs of its first principles before asserting them, as it would be for the 'heart' to demand of the 'reason' a feeling of all propositions that she demonstrates before accepting them. This weakness, therefore, should only serve to humble reason in its desire to make itself judge of everything, but by no means to moderate the certitude of our conviction, as if reason were alone capable of instructing us."[1]

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[1] *Pensées.*

[2] "Prière pour demander à Dieu le bon usage des maladies," *Œuvres*, ii. pp. 28–34.

Here comes out Pascal's theory of belief: it rests on the heart, not on the intellect alone. He had no faith in the Cartesian philosophy. That he flung to the winds; and in this circumstance alone could Cousin find the shadow of an argument in support of his accusation. Pascal did not rest his conviction on reasoning. The mere fact that he had "arrived at a deeper ground of certitude, whether he has made it clear or not, and whether or not he has spoken with undue depreciation of other sources of knowledge, should be enough to vindicate him from the charge of even philosophical scepticism."[2] It is amongst the curiosities of literary history, first that Descartes should be placed at the head of modern sceptics, and next that Pascal should also be called a sceptic, and that because he opposed Cartesianism.

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[1] Faugère, ii. p. 108; Tulloch, p. 188. Passages in Pascal on Pyrrhonism may be found in *Œuvres Complètes*, i. pp. 254, 260.

[2] Tulloch, p. 188. See more on the subject by Rogers in his *Essays*, and Vinet in his *Studies on Pascal*.

Another and an equally unreasonable suggestion with reference to Pascal in his latter years is that his mind became enfeebled by disease, and that his religious opinions were the result of mental weakness. This line of remark has been applied to others as well as Pascal, but never more unfortunately than in his case. It is sufficient to repeat the observation of his last biographer, Principal Tulloch:

"Whatever explanation we may give of the supposed incidents attending Pascal's conversion, there never was a more absurd fancy than that Pascal's mind suffered any eclipse in the great change that came to him. He may have been credulous, he may have been superstitious: the miracle of the Holy Thorn may be an evidence of the one, and the unnatural asceticism of his later years a proof of the other. But to speak of the author of the *Provincial Letters,* of the problems on the cycloid, and finally of the *Pensées,* as if his intellect had suffered from his conversion, is to use words without meaning. All his noblest writings were the product of his religious experience, and he never soared so high in intellectual and literary achievement as when moving on the wings of spiritual indignation or of spiritual aspiration." As to the real piety of Pascal there can be no question. He was no mere theorist, no mere sentimental professor of religion; what he professed he believed, and what he believed he practised. As a Roman Catholic, of course, his religious life was tinctured by his theological and ecclesiastical opinions. He did not like the Jesuits. He exposed their policy. He abhorred the vices of their system. He was no Ultramontanist, but he was a decided Catholic, in sentiment and practice, and exceeded most persons in the severity of his asceticism and self-denial; in this respect carrying out the Saviour's injunction to bear the cross to an extreme which ought to have been checked by other portions of Divine teaching. To such a case we well apply the poet's words—and "yet the light which led astray was light from Heaven." Also the matter of the Holy Thorn, and some other circumstances indicative of credulity and superstition, already indicated, are drawbacks on the religious character of this extraordinary man. But no Protestant, however decided in his aversion to popery, if he has in him a spirit of true catholicism, can fail to do honour to one so good and great as an illustrious member of the universal "communion of saints."

Pascal died as he lived, a pious Jansenist, holding to that side of theology which is presented in the writings of St. Augustine. He shrunk from everything like Pelagianism, and trusted not to his own good works, but to Divine grace. He gradually sunk under the weight of his infirmities, yet glorying in them, as did the Apostle Paul, that the power of Christ might rest upon him. It had long been his favourite idea, that pain and suffering are the proper discipline for a Christian, so that, beyond most modern believers, he rejoiced "in tribulation also." He wished to die in the Hospital of the Incurables, but was too weak to be carried there. The minister of St. Stephen's, when he came to administer the Eucharist, exclaimed, "Behold Him whom you have so long desired." When the sacrament was over, which he had received with tears, the dying man cried, "May God never leave me!"

Pascal died on the 19th of August, 1662.

ISAAC BARROW.

1630 (?)–1677.

FRENCH encyclopedists have spoken of him as an obscure theologian and a well-known mathematician. How judgments alter at different periods and in different countries! Whatever might be said on the Continent during the last century in reference to the man whom we are about to describe, in England, at the present hour, his fame as a divine far exceeds his fame as a philosopher. But beyond all question, in both capacities he was so eminent that he forms a most appropriate instance of a close association of science with religion.

Barrow seems to have been one of those extraordinary persons who make a mark in history by traditions of their personal character and influence. There are some men who have not written much, who never achieved any great exploits, and yet their names shine with a brilliant lustre in biographical annals. Such are Whichcote, the Cambridge scholar of the seventeenth century, and Selden, the learned member of the Long Parliament; and we may add, Matthew Hale, the wise and righteous judge. They indeed were authors, and wrote works well worth reading; but it is chiefly as men of character, of power, of influence while they lived, that they have been remembered, and will continue to be so, generation after generation, now they are dead. Barrow belongs to the same class in this respect, that whilst his theological works retain a conspicuous place in our literature, and are read more or less by theological students, there is a superadded interest connected with his name, derived from descriptions and anecdotes of his person, his habits, his conversation, and his general demeanour. His presence seems to have had about it something very peculiar, for he was exceedingly thin, and low of stature, and negligent in dress; and yet, if we may judge from his comely portrait, his regular features, handsome nose and mouth, bright grey eyes, and gracefully curling locks, he must, as he advanced in life, have won respect by his very appearance. Of his conversational powers, his wit and humour, we have striking examples.

No master of wit ever gave such a clever description of this mental quality as did he. "Sometimes it lieth in past allusion to a known story, or in seasonable application of a trivial saying, or in forging an apposite tale; sometimes it playeth in words and phrases, taking advantage from the ambiguity of their sense, or the affinity of their sound; sometimes it is wrapped in a dress of humorous expression; sometimes it lurketh under an odd similitude; sometimes it is lodged in a sly question, in a smart answer, in a quirkish reason, in a shrewd intimation, in cunningly diverting or cleverly retorting an objection; sometimes it is couched in a bold scheme of speech, in a tart irony, in a lusty hyperbole, in a startling metaphor, in a plausible reconciling of contradictions, or in acute nonsense;

sometimes a scenical representation of persons or things, a counterfeit speech, a mimical look or gesture passeth for it; sometimes an affected simplicity; sometimes a presumptuous bluntness giveth it being; sometimes it ariseth only from a lucky hitting upon what is strange; sometimes from a crafty wresting obvious matter to the purpose; often it consisteth in one knows not what, and springeth up one can hardly tell how. Its ways are unaccountable and inexplicable, being answerable to the numberless rovings of fancy and windings of language." Sydney Smith says this is not a definition of wit, but a description.[1] Very true; and the distinction between definition and description is often overlooked, but there are many objects which refuse to be defined, and yet delight to be described; and of the superior charm as well as the greater usefulness of the latter there can be no question.

Barrow's great animal courage and his singular moral humanity and conscientiousness are also worthy of remark. Walking about the premises of a friend one evening, he was attacked by a fierce, unchained mastiff. He struggled with the creature and threw him down, and actually obtained such power over the animal as to feel he could strangle him; but he reflected the dog was only doing his duty in seizing a stranger who had no business in the place, that the dog did not know him, and that therefore he did not deserve to die for what he had done. But he durst not loose his hold, lest the beast should tear his victim, so he laid his whole weight on the mastiff, and so remained until somebody came to his assistance.

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[1] Sydney Smith's *Lectures*. Lecture on "Wit."

Barrow's face, with its pleasant features, was not always sufficient to produce a good impression. This appears from an amusing story told of his preaching at St. Lawrence Jewry, soon after the Restoration; but it is evident that his negligent attire more than anything else had to do with the odd impression he produced. "Slovenly and carelessly dressed, his collar unbuttoned, and his hair uncombed," he so alarmed the congregation that "the pattens of the serving maids," "the unlocking of the pews, and the cracking of the seats caused by the younger sort climbing over them," made a spectator think that the people were mad. When all was over an apprentice accosted him, saying, "Sir, be not dismayed, for I assure you 'twas a good sermon." When asked what he thought of the folks rushing out, Barrow calmly replied, "I thought they did not like me or my sermon; and I have no reason to be angry with them for that." "What was your opinion of the 'prentice?" some one asked. "I take him," replied Barrow, "to be a very civil person; and if I could meet with him, I'd present him with a bottle of wine."[1]

The length of his sermons was notorious. Once, before he preached in Westminster Abbey he was requested to be short. He showed the MS. to the Dean, who requested that only half should be delivered; but the half occupied an hour and a half. On another occasion he so "enlarged" that the vergers, who were anxious to show impatient visitors "the tombs and effigies of the kings and queens in wax," "caused the organ to be struck up against him, and would not give over playing till they had blowed him down." His Spital sermon took three hours and a half in the delivery; and when asked if he did not feel tired, he replied, "he began to be weary of standing so long."[1]

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[1] Pope's *Life of Ward*, p. 148.

With regard to the early life of this extraordinary person, it is sufficient to state that he was a linen-draper's son, and a bishop's nephew. He was born about 1630, and was educated at the Charterhouse. In 1643 he entered at Peterhouse College, Cambridge, where his uncle was at that time fellow; and in 1645 he removed to Trinity, where he obtained a fellowship. His attachment to episcopacy made him suspected by Presbyterians, yet he overcame dislike by his personal qualities. "Thou art a good lad. 'Tis pity thou art a Cavalier," said the Puritan master of his college. "Barrow is a better man than any of us!" exclaimed the same college Don, when the young gownsman had given offence by one of his Latin orations.

Physics as well as metaphysics early secured his attention, together with ethics and theology; and we find him dealing, in his academic exercises, with the Cartesian hypothesis of matter and motion. The works of Galileo and Bacon were at the same time studied by this promising youth; and when he had attained his fellowship in 1649, before he came of age, he resolved to apply himself to the study of medicine. This was because, with his ecclesiastical opinions, he saw, at that period, no hope of his becoming a clergyman. Anatomy, botany, chemistry, now occupied his time; and in these studies he had for a companion and friend the amiable and ingenious John Ray, who will be noted in a future chapter. Struck by Scaliger's notes to Eusebius, Barrow saw the dependence of chronology on astronomy, and then began to master Euclid. Conic sections excited his curiosity, and his geometrical inquiries soon placed him as a philosopher far ahead of John Ray. In 1655 he published an edition of *Euclid's Elements*, and two years afterwards issued the *Data*. Unlike most editors of Euclid, he has given us the fifteen books of the elements entire, occasionally substituting demonstrations of his own, or shortening and simplifying those of his author.

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[1] Pope's *Life of Ward*, p. 148.

In 1654 Barrow tried for a Greek professorship, but failed, and then went abroad. He visited Paris, and in a letter to his college thus describes, in stilted style, such as was the fashion of the age, the state of French society :

"Here public affairs present an aspect of external tranquillity. Everywhere peace smiles with benignant aspect. The whole kingdom throughout, the din of arms is not heard. Without, fortune flatters with prosperity ; within, all is afloat in luxury. In the palace, magnificence and revelry hold court. All is an endless round of play-acting, dancing, feasting, rejoicing, every man in his humour, and no day of evil coming. But what security there is for all this felicity, what heavings toward a storm may agitate the bosom of this deep, and what tempests may be struggling forth from the caverns of clandestine consultation, the more knowing must determine. The seeds of mischief have not yet shot through the thin mould that covers them; but perpetually watered as they are, it is easy for sharp eyes to see how far their roots are striking. For where violence is the basis, who can guarantee stability? and who can pledge the patience of an afflicted people, whilst the hooks of a ceaseless extortion are raking in their vitals? (cujus viscera perpetuis exactionum hamis exenterantur?) Where the memory of past wrong and the sense of present grievance inflame them against the nobles; where the administration of law is confided not to men of legal skill or blameless character, but to the best bidder; where military and civil promotion is irrespective of merit, and the strongholds of the public safety are opened by a golden key; where the soldiers, having lavished their lives for the common weal, get promises for pay, and count it good luck when they get a tenth of their wages; where, in short, the people are retained in allegiance not by the silken cords of kindness, but by the reins of terror and the force of fear; where such scandals strike every eye, what tranquillity can be lasting?"[1]

He afterwards visited Constantinople, and there studied the sermons of Chrysostom. Those wonderfully effective orations, interesting anywhere, became doubly so in the city where they were delivered; and in the capital of the Christian Greek empire, Barrow no doubt improved that ability for eloquent argument and declamation which shines with such lustre in his sermons. He is the John Chrysostom of the English Church; not that Barrow as a preacher from the pulpit ever approached his patristic model, but as a preacher from the press he often reminds us of the man whom a friend of ours described as the Joshua of the early

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[1] Hamilton's *Life of Barrow*, prefixed to his Works, i. p. xviii.

Church, that stayed the sun of Grecian eloquence from going down for a whole day.

On Barrow's return to England in 1659, just on the eve of the Restoration, he resolved to devote himself to the Christian ministry, and obtained episcopal orders at the hands of old Bishop Brownrigg; and here the candidate's wit came into play. "*Quid est fides?*" asked the prelate. When the rest of the young men had answered as well as they could, Barrow said, "*Quod non vides.*" The bishop exclaimed, "*Excellenter!*" A second interrogation went its round, "*Quid est spes?*" When it came to Barrow's turn, he responded, "*Nondum res.*" "*Bene, bene, excellentius!*" the examiner added, delighted with the answer. Then followed the third question, "*Quid est caritas?*" "*Ah, magister,*" said young Barrow, "*id est paucitas.*" "*Excellentissime!*" shouted the old gentleman; "*aut Erasmus est aut diabolus.*"[1]

On his return to Cambridge Barrow secured, after the Restoration, what he had before sought in vain—a Greek professorship; but he does not seem to have been at all popular in that capacity. Science was more to his taste and to his peculiar abilities. In 1662 he became professor of geometry in Gresham College, London, and sometimes assisted his friend, Dr. Pope, in the duties connected with the chair of astronomy. In 1663 he accepted the professorship of mathematics at Cambridge, a professorship just founded by Mr. Lucas, and at the same time he resigned his office at Gresham College.

"The gradual exclusion of mental by physical science from the circle of philosophy, as defined in the Cambridge schools, belongs to the first half of the eighteenth, not of the seventeenth century," says the learned author of the *Life of Thorndike*, that eminent Cambridge scholar; but the same writer justly adds, "that in the seventeenth century ancient philosophy and languages were yielding to the continually increasing influence of mathematics and natural philosophy."[1] Signs of the change are traceable in Barrow's life; and perhaps the want of popularity which we notice in connection with his Greek professorship, might be owing to a decline of enthusiasm in that direction, as well as to certain admitted defects in the professor himself. His career as a scientific teacher appears to have been more successful, and his inaugural discourse testifies to his high appreciation of the class of studies to which he invited his pupils.

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[1] Quoted in Allibone's *Dict.*, art. "Barrow."

The philosophical works which Barrow published, or which, written by him, were given to the world after his death, are numerous. They include his *Euclidis Elementa*; *Euclidis Data*; *Lectiones Opticæ*; *Lectiones Geometricæ*; *Lectiones Mathematicæ*; and an edition of Archimedes, Apollonius and Theodosius.

Professor Playfair praises the lectures on optics delivered at Cambridge as treating of "all the more difficult questions which had occurred in that state of science, with the acuteness and depth which are found in all the writings of that geometer;"[2] and Dugald Stewart speaks of his inventive genius in mathematics as securing to him "a rank second alone to that of Newton."[1] Newton was one of Barrow's pupils; and it certainly redounds to the honour of both, that each had so high an opinion of the other. Newton urged Barrow to print his *Lectiones Opticæ,* and Barrow states in his preface, with complimentary epithets, that Newton had revised the text, suggested corrections, and supplied additional matter out of his own stores.

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[1] Thorndike's Works, vol. i. p. 166.

[2] Preliminary Dissertation in *Ency. Brit.*

"The value of Barrow's mathematical labours has been underrated by some recent writers. The following is the fairest estimate of their importance which we remember to have met with: His *Lectiones Geometricæ* are filled with profound investigations respecting the properties of curvilineal figures; and in the method of tangents which he has explained in that work, we clearly discover the germ of the fluxional calculus. This ingenious method, which is a great simplification of the rule given by Fermat, differs in nothing but the notation, from the method of finding the subtangent by the differential calculus. The optical lectures of Dr. Barrow are distinguished by the same original views which characterize his lectures on geometry. His beautiful theory of the apparent place of objects seen by refraction or reflection, and the elegant determinations which he has given of the form of the images of rectilineal objects received from mirrors and lenses, entitle him to the highest praise. By pushing these researches a little farther, Barrow could not fail to have discovered the caustic or Tschirnhausenian curves."[2] "To this we have only to add the service which he rendered to mathematical science by restoring the works of some of its great fathers. To publish improved editions of Euclid, Archimedes, Apollonius, and Theodosius, should of itself have procured for Barrow a place of note in the history of mathematical learning. But he had a still more original merit in the improvements which he introduced into the language of geometry. He discarded many of the cumbrous circumlocutions which had been considered essential to the ancient strictness, and by a judicious employment of symbols did much to promote its perspicuity. At the same time he had too high veneration for the approved methods of antiquity, to substitute in their place the notation which then began to prevail. For this he was often commended by Newton."[1]

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[1] Preliminary Dissertation in *Ency. Brit.*

[2] *Edin. Ency.*, art. "Barrow."

In the year 1669 Barrow resigned the mathematical chair in favour of his illustrious pupil. A great change had come over him; and now he wished to devote the remainder of his life to theological pursuits. It is plain that he felt, though science has its claims, there is one subject which has still higher attractions, because it is connected with the moral and spiritual welfare of mankind beyond every other department of human knowledge. Barrow the philosopher now merges in Barrow the divine.

He spent his days as Fellow of Trinity reading his Bible and religious literature and writing sermons, some of which he preached, but more have been printed. A small sinecure in Wales, to which he was presented by his uncle, the Bishop of St. Asaph, and a stall at Salisbury, given him by Bishop Seth Ward, were the only pieces of Church preferment he received, and they brought no increase of wealth to the holder, as he devoted the proceeds to works of charity. In 1672 he reached the summit of his ambition, being then promoted to the Mastership of Trinity, as successor to Dr. Pearson, the renowned author of an exposition of the Creed. King Charles II. at the time of appointing Barrow remarked, that he had bestowed the mastership on the "best scholar in England." The statutes allowed the master to marry; but Barrow did not avail himself of the privilege, and remained a somewhat eccentric bachelor to the end of his life. Trinity College was his wife; and he loved that college with a devoted affection. Perquisites which were his due he remitted, in order to promote the erection of a library, and his zeal in raising funds for the purpose knew no bounds. The building is Barrow's best architectural monument. At Trinity he spent the remainder of his days. "And in this place," says his biographer, Hill, "seated to his ease and satisfaction, a station wherein of all others in the world he could have been most useful, and which he meant not to make use of as a step to ascend higher, he abated nothing of his studies. He yielded the day to public business, and took from his morning sleep many hours to increase his stock of sermons, and write his treatise on the *Pope's Supremacy*. He understood popery both at home and abroad; he had narrowly observed it militant in England, triumphant in Italy, disguised in France; and had earlier apprehensions than most others of the approaching danger, and would have appeared with the forwardest in a needful time." [1]

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[1] Pemberton's *View of Sir I. Newton's Phil.*, Pref. Hamilton's *Life of Barrow*, prefixed to his Works, p. xxix.

Barrow approached Christianity on its moral side. He was one of those who love to sit at the Master's feet and listen to the Sermon on the Mount. The bent of his mind, the habits of his thoughts, the disposition of his heart probably inclined him in this direction; but it is also likely that a reaction produced by the angry doctrinal discussions of the age contributed to the effect. No one can read the account given by Richard Baxter and others of the theological discussions which went on during the civil wars, of the verbal battles which were fought amongst the parliamentary soldiers in moments when there was a suspension of arms, without seeing how the air of England was at that time impregnated with a spirit of dogmatical contention which often degenerated into mere logomachy. This disturbance of the social atmosphere continued afterwards, and the consequence was, that many peaceful Christians were tempted to avert their attention from themes around which there had been thrown thick clouds of dust. Barrow had evidently no liking for some of the questions in dispute amongst Cromwell's soldiers, and the ultra-Puritans of the next generation. Supralapsarian and Sublapsarian aspects of the Divine decrees had no charms for him, and he greatly preferred to study moral duties enjoined in the New Testament. No man, perhaps, ever more excelled in the understanding and inculcation of Christian ethics than did he. The government of the tongue, the folly of slander, the wickedness of detraction, the obligation of quietness and doing our own business, the love of our neighbour, the motives and acts of charity, the beautifulness of a peaceable temper and carriage, the excellence of a diligent and useful life—these and similar subjects were unweariedly revolved in Barrow's mind and wrought into his discourses. He has two sermons on industry in general, and three in particular on industry in our callings. He takes up separately industry in our calling as Christians, industry in the calling of gentlemen, and industry in the calling of scholars—topics most suitable in a university pulpit. But with these moralities he associated the motives and impulses afforded by the gospel; and therefore he dwelt on the love of God, the duty of doing all things in the name of Christ, the imitation of the perfect example, and "the passion of our blessed Saviour." With a flow of thought and an affluence of language rarely approached, never surpassed, the eminent mathematical philosopher took the highest place in English literature as a Christian moralist. What is best of all, Barrow practised what he preached. His life was a beautiful example of Christian virtue, a reflection of the mind and spirit of his Master. "Of all the men," says Archbishop Tillotson, "I ever had the happiness to know, he was the freest from offending in word, coming as near as is possible for human frailty to do to the perfect idea of St. James, his perfect man." "All I have said or can say," remarks one of his biographers,[1] "is far short of the idea which Dr. Barrow's friends have formed of him, and that character in which he ought to appear to them who knew him not. Besides all the defects on my part, he had in himself this disadvantage, of wanting foils to augment his lustre, and low places to give eminence to his heights; such virtues as his, contentment in all conditions, candour in doubtful cases, moderation among different parties, knowledge without ostentation, are subjects fitter for praise than narrative."

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[1] Quoted by Hamilton, p. xxxii.

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[1] Abraham Hill.

His argumentative power appears in his reasonings on behalf of the truth and divinity of the Christian religion. The reasonableness of faith in a Divine revelation he maintains in the following characteristic passage:

"We cannot, indeed, judge or determine concerning the special circumstances or limits of God's dealing towards man in this particular; concerning the time when, the manner how, the measure according to which, God will dispense those revelations of Himself; those depend upon mysteries of counsel and wisdom surpassing our comprehension. That God should for a while connive at men's ignorance, and suffer them to grope after Divine truth; to try them, as He did the Israelites in the wilderness, how they would behave themselves in that state; to prove how they would use their talent of natural light, to make them sensible of their own infirmity, to show them whence all their welfare must proceed, on whom all their happiness depends, to make them more able to value, more desirous to embrace, the redress vouchsafed them; as also to demonstrate His own great clemency, long-suffering, and patience; that, I say, for such purposes, and others unsearchable by our shallow understanding, God should for some time forbear with a full evidence to declare all His mind to men, is not so strange or unlikely; but that for ever, through all courses of time, He should leave men in so forlorn a condition, in such a depth of ignorance, such perplexity of doubt, such captivity under sin, such subjection to misery, seems not probable, much less can it seem unprobable that He hath done it; it cannot, I say, in any reason seem misbecoming the goodness, wisdom, or justice of God, clearly to discover to us what He requires us to do, what good He intends for us, what way leads to our happiness, how we may avoid misery. This consideration, if it do not prove peremptorily that God cannot but sometime make such a revelation, nor that He yet hath actually done it (forasmuch as we cannot reach the utmost possibilities of things, nor are fit judges of what God must necessarily do; although to my apprehension, this sort of reasoning, with due caution used, subsisting in general terms, and not over precisely applying it to particular cases, implicated by circumstances and specialities not falling under our judgment, hath great force); yet it removes all obstruction to our belief, and disposes us with more readiness to admit the reasons which follow: for it being not unprobable, yea, according to the reason of the thing, very probable, that He should do it, we have cause with attention and expectation of success on this hand to regard the arguments that pretend to prove He hath done it."[1]

Barrow has more sermons on the morals of Christianity, and on the evidences of natural and revealed religion, than on what are commonly called the doctrines of the gospel; but it is a great mistake to suppose that he avoided the evangelical element in his reflections and teachings, for he has several sermons filled with what is denominated evangelical truth, and it is remarkable that we find him *quite as much at home* on these as on other themes. It is interesting to learn that "glorying in the cross" was the subject of the last sermon he composed; and the following extract shows how his heart warmed at the thought of the love of our Lord Jesus Christ:

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[1] Works, vol. ii. Serm. 13.

"And how can it otherwise than inflame our heart with love toward the blessed Son of God, our Saviour, to consider that, merely out of charitable pity toward us, He purposely came down from heaven and took our flesh upon Him, that He might therein undergo those extreme acerbities of pain, and those most ugly indignities of shame for us? 'Greater love,' said He, 'hath no man than this, that a man lay down his life for his friends.' But that God should lay down His life, should pour forth His blood, should be aspersed with the worst crimes, and clothed with foulest shame, should be executed on a cross as a malefactor and a slave, for His enemies and rebellious traitors,—what imaginations can devise any expression of charity or friendship comparable to this? Wherefore, if love naturally be productive of love, if friendship justly inheriteth a correspondence in good will, what effect should the consideration of so ineffable a love, of so unparalleled friendship, have upon us?

"How can any serious reflection on this event fail to work hearty gratitude in us toward our good Lord? For put [the] case [that] any person for our sake (that he might rescue us from the greatest mischiefs, and purchase for us the highest benefits) willingly should deprive himself of all his estate (and that a very large one), of his honour (and that a very high one), of his ease and pleasure (and those the most perfect and assured that could be), that he should expose himself to the greatest hazards, should endure the sorest pains and most disgraceful ignominies, should prostitute his life, and in most hideous manner lose it, merely for our sake: should we not then apprehend and confess ourselves monstrously ingrateful, if we did not most deeply resent such kindness, if upon all occasions we did not express our thankfulness for it; if we did not ever readily yield all the acknowledgment and all the requital we were able? The case in regard to our blessed Saviour is like in kind; but in degree, whatever we can suppose doth infinitely fall below the performances of Him for us, who stooped from the top of heaven, who laid aside the majesty and the felicity of God, for the infamies and the dolours of a cross, that He might redeem us from the torments of hell, and instate us in the joys of paradise. So that our obligations of gratitude to Him are inexpressibly great; and we cannot with any face deny ourselves to be most basely unworthy, if the effects in our heart and life be not answerable." [1]

Barrow died in the prime of life, the same month as that in which he preached his passion sermon, April, 1677, the exertion of delivering which brought on cold, which ended in fever.

"The last time he was in London," says Dr. Pope, "whither he came, as it is customary, to the election of Westminster scholars, he went to Knightsbridge to give the Bishop of Salisbury a visit, and then made me engage my word to come to him at Trinity College immediately after the Michaelmas ensuing. I cannot express the rapture of joy I was in having, as I thought, so near a prospect of his charming and instructive conversation. I fancied it would be a heaven on earth, for he was immensely rich in learning, and very liberal and communicative of it, delighting in nothing more than to impart to others, if they desired it, whatever he had attained by much time and study. But of a sudden all my hopes vanished, and were melted like snow before the sun. Some few days after, he came again to Knightsbridge, and sate down to dinner; but I observed he did not eat, whereupon I asked him how it was with him. He answered that he had a slight indisposition hanging about him, with which he had struggled two or three days, and that he hoped by *fasting* and *opium* to get it off, as he had removed another and more dangerous sickness at Constantinople some years before. But these remedies availed him not. His malady proved in the event an inward, malignant, and insuperable fever, of which he died, May 4th, 1677, in the forty-seventh year of his age, in mean lodgings, at a saddler's, near Charing Cross, which he had used for several years, for though his condition was much bettered by his obtaining the Mastership of Trinity College, yet that had no bad influence on his morals: he still continued the same humble person, and could not be prevailed upon to take more respectable lodgings."[1]

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[1] Works, i. p. 321.

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[1] Pope's *Life of Ward.*

ROBERT BOYLE.

1626–1691.

If any one of our countrymen in past days won for himself by indisputable right the title of Christian philosopher, it was Robert Boyle. There are other names more illustrious in the annals of British science; perhaps his genius was somewhat overrated by the contemporary and the succeeding generations; yet that he attained to eminence in the study of natural philosophy is beyond contention, and, perhaps, as an industrious experimentalist he has been rarely equalled. But his religious character comes out with a fulness and a particularity of detail beyond almost any other of our scientific celebrities, in times previous to the present century. There are autobiographical notices of his early life,[1] in which he indicates his spiritual experience; and he published several works on the subject of religion, which reveal to us his devout sentiments no less than his theological opinions.

He was born on the 25th of January, 1626, at Lismore, in the province of Munster, Ireland, being the seventh son of Richard, Earl of Cork; and it is curious to find him thus expressing his satisfaction with the allotment made to him by Divine providence. "It so suited his inclinations and designs that had he been permitted an election his choice would scarcely have altered God's assignment." Free from all worldly ambition, he, to the end of life, declined every offer of elevated rank, putting aside repeated requests to accept a peerage, though that honour was embraced by one of his brothers. Several hairbreadth escapes, which he notices in his autobiography, with fervent gratitude to the Almighty, marked his boyhood; and at eight years of age he went to Eton, whilst the famous Sir Henry Wotton was provost of the college, and there he devoted himself to learning with an extraordinary diligence, which betokened subsequent distinction. As we picture him a lad in the beautiful playing-fields near the Thames, wandering under the shade of noble trees, or sitting on the banks of the great English river, we can easily imagine how his love of nature would even then find room for vigorous play, and how he would begin to speculate upon the currents of air which fanned his cheeks, and the flow of water running at his feet. We find that at the time he was fond of reading, and diverted himself with the Romance of *Amadis de Gaule;* and that afterwards he found it necessary to counteract irregular mental habits, the most effectual way being, he says, "the extraction of the square and cube roots, and especially those more laborious operations of algebra, which so entirely exact the whole man that the smallest distraction or heedlessness constrains us to renew our trouble, and rebegin the operation."

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[1] These are incorporated in the *Life of Boyle* by Birch, prefixed to his *Works*, six vols. 4to.

In 1638, just before the opening of tho Civil Wars, he set out upon a tour and residence abroad, which lasted through four years; when he improved his knowledge of continental languages, especially French, which he had learned as a little child, in spite of stuttering,—brought on, it appears, by a foolish habit of mocking other children. In company with an elder brother, under the care of M. Marcombe, a Frenchman, to whom he acknowledged himself under great obligations, he settled down in the city of Geneva, and there industriously prosecuted his studies. Whilst residing in that city he was startled one night by a tremendous thunderstorm, which seemed to him like the harbinger of the Judgment Day. Though of virtuous life, Christ, to use Boyle's own words, was asleep in his conscience, as He once was asleep in a ship, and He must now be wakened by a storm. He thought the Day of Judgment was at hand, whereupon the consideration of his unpreparedness to welcome it, and the hideousness of being surprised by it in an unfit condition, made him resolve soon that if his fears were that night disappointed, all further additions to his life should be more religiously and watchfully employed.[1] The morning came, and a serene, cloudless sky brought influences to his mind, typical of other and higher Divine operations, when he ratified his determination thenceforth to serve wholly the Author of his being. From Geneva he proceeded to Italy, visited Florence, no doubt ascended to Fiesole, learned the language of the country, and employed himself "in the new paradoxes of the great stargazer

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[1] *Life* by Birch, p. xxii. The passage is from the autobiography, written in the third person under the name of Philaretus.

Galileo, whose ingenious books, perhaps because they could not be so otherwise, were confuted by a decree from Rome."[1]

He returned to London in 1644, after his father's death, when England was divided between hostile armies, and Charles I. and the Parliament were struggling for the mastery, with what result every reader knows. Strange to say, Boyle took no sides in the all-engrossing conflict, whence came this advantage, that he escaped the enmity of both parties; and when others had their property confiscated by one or other of the belligerents, he, unmolested, retained his ample estates and possessions.

He was a man formed for quiet study, not for political action. He had no fitness and no inclination for the duties and honours of statesmanship. Nor had gay society any charms for him; neither did he throw himself into the arms of the Puritan party, or adopt their characteristic habits of social life. He visited his Irish estates, heard there enough of his native country's divisions, strifes, bloodshed, and miseries; tried to do what good he could; and then, after a wandering but studious career for a long period, settled down at Oxford from 1654 to 1668. He cultivated at Oxford the exact sciences, and, as an experimentalist, perfected the air-pump, in conjunction with his friend Hook. During the same period he prosecuted the study of the sacred languages and Biblical theology with his friends Pococke, the Orientalist, Barlow (afterwards Bishop of Lincoln), and Samuel Clarke. Upon the restoration of Charles II., and the re-establishment of the Episcopal Church, friends, knowing the strong religious bent of his character, tried to persuade him to enter into holy orders; but he declined, chiefly on this ground, that he felt "no inward call, no Divine monition" in that direction; moreover he wished for leisure which he might devote to scientific and theological pursuits. He thought that as a layman he could render more service to Christianity and his country, than he could by adopting the ministry as a profession. He had an elder sister, Lady Ranelagh, whom he dearly loved; and with her he threw in his lot for life as an unmarried man. They resided together in London after the close of his Oxford residence.

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[1] *Life* by Birch, p. xxiv.

Philosophy he made one of his chief employments; and in connection with his enthusiastic pursuit of its objects we must notice at once the founding and early history of a national institution which has long been the pride of England, namely, the Royal Society of London. In the midst of the Civil Wars—when battles and sieges were the order of the day, and it would seem, as we read the history of the so-called Great Rebellion, impossible that people could then betake themselves, with anything like tranquillity, to the retired employments of life,—we find that not only could good Izaak Walton go a-fishing by the side of the Lea and in the depths of the romantic Dovedale, but there arose at the same time "a group of philosophers who began to knock at the door where truth was to be found."[1] They belonged to both sides of the political conflict, or took no part in it at all, but in the study of science they found a basis of fellowship and co-operation. It is worth mention that Gascoigne, the inventor of the micrometer, fell at Marston Moor; Milbourne, the astronomer, lost his scientific papers through the invasion of the Scotch army in 1639; and Harvey's anatomical preparations were plundered and destroyed in the confusion of the war. But others, whom a happier lot befel, managed not only, each in his own way alone, to interrogate nature, and wait for her answer, but to unite together in such interrogations, and in a common patient waiting for her replies. Wilkins, Warden of Wadham, Oxford, appointed by Parliament, and afterwards Master of Trinity, Cambridge, under Richard Cromwell, at last made Bishop of Chester by Charles II.; Seth Ward, of Sidney College, Cambridge, deprived by the Parliament, and then after the Restoration appointed Bishop of Salisbury; and Wallis, once a Fellow of Queen's, Cambridge, then Savilian Professor at Oxford, in which office he was confirmed by Charles II.,—these all took a leading part in the formation of the new society; and it is not unworthy of notice that in all this we see how strongly imbued with a scientific spirit were certain men, at that time, who had devoted themselves to the work of the Christian ministry. Christopher Wren was also of the number, and Robert Boyle from the beginning was an active member of the band. So early as 1645, divers worthy persons, inquisitive into natural philosophy and other parts of human learning, did by agreement meet weekly in London on a certain day to treat and discourse of such matters. Wallis relates that when they met they talked about "the circulation of the blood; the valves in the veins; the venæ lactæ; the lymphatic vessels; the Copernican hypothesis; the nature of comets and new stars; the satellites of Jupiter; the oval shape of Saturn; the spots in the sun, and its turning on its own axis; the inequalities and selenography of the sun; the several phases of Venus and Mercury; the improvement of telescopes, and grinding of glasses for that purpose; the weight of air; the possibility or impossibility of vacuities, and nature's abhorrence thereof; the Torricellian experiment in quicksilver; the descent of heavy bodies, and the degrees of acceleration therein; and divers other things of like nature."[1] The infant association became incorporated in 1662, under Charles II., who gave them a mace, and subscribed his name in the charter book; and in 1664–5 they published the first number of their philosophical transactions. Robert Boyle regularly attended the meetings of this "Invisible College," as it was called, and contributed to its publications. In 1680 he was elected president, an honour which he declined from his scruples as to the religious tests and oaths which were required.

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[1] Whewell, *History of Inductive Sciences*, vol. ii. p. 112.

There were scientific men on the Continent, enthusiastic in their admiration of the English philosopher; and Boerhaave exclaimed, "To him we owe the secrets of fire, air, water, animals, vegetables, fossils; so that from his works may be deduced the whole system of natural knowledge."[2]

Boyle is spoken of by Sir John Herschel as "animated by an enthusiasm of ardour which hurried him from subject to subject, and from experiment to experiment, without a moment's intermission, and with a sort of undistinguishing appetite;" but he was one of the advance party who were destined, under Sir Isaac Newton; to be led into the land of scientific promise. "As facts multiplied, leading phenomena become prominent, laws began to emerge and generalizations to commence; and so rapid was the career of discovery, so signal the triumph of the inductive philosophy, that a single generation, and the efforts of a single mind, sufficed for the establishment of the system of the universe on a basis never after to be shaken."[1]

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[1] *History of the Royal Society.*

[2] Quoted in Allibone, art. "Robert Boyle."

Boyle's scientific writings were numerous. They include works on the air, on chemistry, on experiments, on hydrostatical paradoxes, on absolute rest in bodies, on the weight of water, and on the vulgarly received notion of nature. These books have long since passed out of notice, save as antiquarians in science, inquiring after the progress of knowledge, take them down, covered with dust, from old library shelves; but they contain the results of an amazing deal of quiet persevering observation and experiment, and of speculative ventures into new fields of curiosity. They indicate that preparatory service which, however smiled at by modern proficients, paved the way for the boasted attainments of our own times. Boyle could not rid himself of old prejudices and delusions. We find him deep in inquiries about the transmutation of metals; but the alchemist of the seventeenth, like the alchemist of the thirteenth century, was a pioneer in paths leading up to the discoveries of modern chemistry.

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[1] Herschel's *Discourse on Natural Philosophy*, p. 116.

The grand discovery of Robert Boyle was the scientific law which bears his name—the Boylean law of the air's elasticity. Experiments made by him in 1650 resulted in the knowledge that, in compression, the density of air is as the pressure of air. Accordingly, if the pressure of the common atmosphere be equal to thirty inches of mercury, indicated by the barometer, if air in a tube be pressed by thirty additional inches, the density of the column will be doubled, the air being forced into half the space; and so likewise, a threefold increase of pressure will produce a threefold amount of density. This law of atmospheric elasticity has received the title of the law of Boyle and Mariotte, because Mariotte, in 1676, confirmed experimentally the principle laid down by Boyle.[1]

Boyle's industry is admitted on all hands: the only difference of opinion relates to its results. Mr. Brand says, "Boyle has left voluminous proofs of his attachment to scientific pursuits; but his experiments are too miscellaneous and desultory to have afforded either brilliant or useful results." "He who would do justice to Boyle's scientific character must found it rather upon the indirect benefits which he conferred, than upon any immediate aid which he lent to science."[2] But M. Libes, in his *Hist. Phil. du Progrès de la Physique,* devotes a chapter to the "progrès de la physique entre les mains de Boyle," and states that the air-pump as used by him became a new machine, and that it is impossible to follow him without being struck at the greatness of his resources for "tearing out" the secrets of nature. The discovery of the propagation of sound by the air, "of the absorbing power of the atmosphere, of the elastic force and combustive power of steam, the approximation to the weight of the air, the discovery of the reciprocal attraction of the electrified and non-electrified bodies, are mentioned as additions to the science." Another writer, in Knight's *Biographical Dictionary,* observes that between the characters implied in the two preceding authorities, we have no doubt the true one. "The science of mechanics must have originally stood to chemistry much in the same relation as the objects of botany to those of mineralogy: the first presenting themselves, the second to be sought for. The mine was to be found as well as worked; and every one who sunk a shaft diminished the labours of his successors by showing at least one place where it was not. In this point of view, it is impossible to say to what degree of obligation chemistry is to limit its acknowledgments to Boyle. Searching every inlet which phenomena presented, trying the whole material world in detail, and with a disposition to prize an error prevented, as much as a truth discovered, it cannot be told how many were led to that which does exist, by the previous warning of Boyle as to that which does not."[1]

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[1] Whewell, *Hist. of Inductive Sciences,* vol. ii. p. 407.

[2] Supp. *Ency Brit.,* edit.

Whewell remarks that Boyle's disposition led him to suspect all generalities; but, at the same time, that the development of the notion of chemical attraction gradually made way among the chemists of the latter part of the seventeenth, and the beginning of the eighteenth century, as may be seen in the writings of Boyle, Newton, and their followers.[1]

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[1] Art. "Boyle."

Boyle's theological publications were also numerous. He wrote on seraphic love, the high veneration man's intellect owes to God, on the style of the Holy Scriptures, the excellency of theology, considerations about the reconcilableness of reason and religion,[2] and on final causes, in which he says, that though it would be erroneous to maintain that all things in the visible world were made for man, yet it is more erroneous to say that all the ends are investigable by man.

In Boyle's works, devoutness of spirit in connection with investigation of the Divine works is very apparent. "I must needs acknowledge," he says, "that when with bold telescope I survey the old and newly discovered stars and planets that adorn the upper region of the world; and when with excellent microscopes I discern in otherwise invisible objects the inimitable subtlety of nature's curious workmanship; and when, in a word, by the help of anatomical knives, and the light of chemical furnaces, I study the book of nature, and consult the glosses of Aristotle, Epicurus, Paracelsus, Harvey, Helmont, and other learned expositors of that instructive volume, I find myself oftentimes reduced to exclaim, with the psalmist, 'O Lord, how manifold are Thy works! in wisdom hast Thou made them all.' And when I have been losing myself in admiration of what I understand not, but enough to admire, and not to comprehend, I am often obliged to interrupt or break off my inquiries by applying to the works of God's creation the expression used by St. Paul of those of His providence, 'Oh the depth of the riches both of the wisdom and knowledge of God! how unsearchable are His judgments, and His ways past finding out!'"[1] To the same effect is the sentiment with which he concludes the articles of his will in reference to the Royal Society, "praying that they, and all other searchers into physical truths, may cordially refer their attainments to the glory of the great Author of nature, and the benefit of mankind."[2] His common conversation on scientific subjects indicated that this was the bent and purpose of his own spirit; and to apply to the subject a figure in his writings, he regarded the works of nature like Elijah's fiery chariot, pure and bright, and of the noblest materials, meant by God to carry up the worshipper to Himself.

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[1] *Hist. of Inductive Sciences*, vol. iii. p. 99.

[2] The theological works of Robert Boyle have been epitomized in three octavo volumes, by R. Boulton, 1715, a very unsatisfactory production. Boyle's works fill six quartos. They certainly contain a number of things hypothetical and very fanciful.

He felt he wanted another teacher besides nature—that he needed not merely *a* revelation, but *the* gospel. From creation he turned to the Scriptures. The observation of the outer and inner world impressed him with a conviction of the existence of a Supreme Power on which he was dependent, and of moral relations to that Power,—relations which conscience made him feel were out of joint; but how to secure reconciliation, purity, and peace, he was well assured he could learn only from God's own Word. He knew what science could do, and what science could not do. He knew how far natural theology could carry him, and where revelation must take him up, or he must be lost. He knew that reason might show him the *want of* salvation, but that only the gospel could show him where the Saviour is found.

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[1] Sentiments of this kind abound in Boyle's *Usefulness of Experimental and Natural Philosophy*.

[2] Appendix to Birch's *Life of Boyle*, p. clx.

The style of the Holy Scriptures he admired, and has written with much quaint eloquence upon the subject; but it was the substance of them, as a communication of Divine Love, which, in his estimation, gave them their chief value. He compared the Bible to Aaron's breastplate, in that it is decked with jewels, and enriched with fair embroidery of gold, and blue, and purple, and scarlet; but what he regarded as of chief value is the insertion—the Urim and Thummim—whereby the Holy One reveals Himself in answer to questions of unparalleled importance and interest. Though he did not gather science from the Bible, yet in its spirit he carried on the pursuits of science. He remembered that the God of both is one; that He who inspired histories, psalms, prophecies, and epistles is He who made stars and flowers; and that the works of His hands never look so fair as when studied in the light of His Word. Nature to him was not so much a volume by which we can find out God, as one from which we may gather illustrations of what God is, having learned His perfection from His revealed truth. It is said of Archbishop Usher, when he grew old, and spectacles could not help his failing sight, that a book was dark, except beneath the strongest light of the windows. The aged man would sit by the casement, with the outspread pages before him, till the sunshine flitted to another opening, when he would change his place, and put himself again under the brilliant rays; so he would move about with the light, till the day was done, and his studies ended. Just so Boyle studied nature by the help of revelation, convinced that our weak eyes will not suffice to make out the entire inscription on the page unless we get near the window, where God pours upon us the radiance of His Spirit.

Boyle was convinced of the reconcilableness of reason and religion, feeling that it is a thing dishonourable to God and mischievous to man to represent reason and religion as antagonistic, since God is the giver of both; and indeed most persons feel, in spite of all sophistry to the contrary, that they ought to be in harmony with both. "For much important matter," observes Bishop Van Mildert, "on the province of reason in judging of revelation, I would earnestly recommend the theological writings of the Honourable Mr. Boyle. No man had more thoroughly considered the extent and limits of the human understanding; none, perhaps, ever combined more perfectly the characters of the philosopher and the theologian." We rise from the perusal of his treatise on *The Reconcilableness of Reason and Religion* with the conviction that Divine religion must be separated from its corruptions; that what man hath taught must not be confounded with Divine teaching; that glosses on Scripture must not be taken for Scripture itself; that reason also must be separated from its corruptions; that what goes by the name of philosophy is not always the same thing as real wisdom; that a narrow, a prejudiced, a proud, a vicious mind is no true oracle of reason, but a false witness: that religion must be taken as *a whole,* and reason must be taken as a whole; that the whole teaching of the one must be studied and compared with the whole teaching of the other; that no single part of the one can be fairly arrayed against a particular portion of the other: that when in their entireness they are contemplated and compared, it will be found that religion is much larger than reason, that they resemble two circular planes, the one of immensely vaster circumference than the other; in short, that there is a border round the edge of religion which reason does not touch. We feel sure that when the former surpasses the latter there is no opposition; but that where they come within a common measurement, there they agree, and cohere as exactly as two discs with polished surfaces: within a certain degree the correspondence of reason and revelation may be established, and if what we can understand is reasonable we may conclude that the rest is so. "If," says Boyle, "God vouchsafes to discover to us in respect of His nature and attributes, what we cannot know without His information, and since we know that whatever He says must be true, we have more reason to believe what He says of Himself and Divine things, than what we should be able to guess at about them by the analogy of things of an infinitely distant nature, or maxims formed according to the nature of inferior things."[1]

It is remarkable that Boyle not only instituted the lecture which bears his name, but in his own writings contributed largely to the literature of what are called

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[1] *The Reconcilableness of Reason and Religion,* book i. part 1.

Evidences of religion. His book on *Final Causes*, in which he opposes the views of Descartes on that subject, abounds in curious facts, illustrative of the wisdom and goodness of God in the works of creation, and we may add, in the words of Dugald Stewart: To him "the world is indebted, besides some very acute remarks and many fine illustrations of his own upon metaphysical questions of the highest moment, for the philosophical arguments in defence of religion which have added so much lustre to the names of Derham and Bentley, and far above both, to that of Clarke. I do not recollect to have seen it anywhere noticed that some of the most striking and beautiful instances of design in the order of the material world which occur in the sermons preached at Boyle's lecture are borrowed from the works of the founder."[1]

His habits of spiritual thought and expression were quite extraordinary, and reveal to us the intense religious emotions which filled his nature. Once he bursts out into the following impassioned exclamation:

"When we have employed the loftiest hyperboles and exhausted all the celebrating topics and figures of rhetoric,—when we have dressed metaphysical abstractions in poetical raptures; when we have ransacked whatever things are most excellent among the creatures, and having defecated them, and piled them up together, have made that heap but a rise to take our soaring flight from; when we have summed up, and left beneath our expressions all that we are here wont to acknowledge above them; nay, when instructed as well as inflamed, and transported by that inaccessible light that is inhabited by what we adore, we seem raised and elevated above all that is mortal, and above ourselves, and say things that nothing else could either inspire or merit; even then, I say, those expressions which any otherwise employed would be hyperboles, do but express our devotion, not the Divine Object of it, and declare how much we honour Him, rather than what He is."

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[1] Dugald Stewart's Preliminary Dissertation, *Ency. Brit.*, p. 139.

His writings are full of a seraphic ardour, working upon an active and vigorous fancy; and though he frequently violates modern canons of taste in literary composition, he presents to his readers a vast variety of images clothed in quaint but picturesque beauty.

Boyle's practical conduct, his general behaviour, his cultivation of social virtues and graces, and his patient submission to the Divine will, are attested by those who knew him, thus proving that he strove to realize what he beautifully describes: "Your making over your whole will to God will impart to you that felicity proportioned to the degree of the resignment. And as the eye, whilst by the optic nerve tied unto the head, so chained, can taste delights which it is dead to being once severed from it, though otherwise it enjoy the best condition of which its inanimate nature can be supposed to be capable; so may your will, by an identity or sameness (in tendency, though not in nature) with your Maker's, as it were engrafted into God's, receive a new and enlarged capacity, which will enable you to contain and relish joys highly transcending those which the fullest fruition of your private wishes were able to create." [1]

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[1] *Of the Style of the Holy Scriptures.*

Piety sanctified all his doings; and, as some one has said: "It was not a thèory, but a practice; and his life expanded itself into a commentary upon his lessons. In the hands of such a man, the arts of human ingenuity become ennobled; and as Burke said of Reynolds, that in painting portraits he appeared not to be raised upon that platform, but to descend to it from a higher sphere; so we may affirm of Boyle, that he came upon the stage of literature with a bloom over his garments that breathed of a remoter and purer climate." His charity was very conspicuous, and was largely laid out in the service of the gospel. It is no wonder that he endowed a lecture which bears his name; but in a man of great literary and scientific habits, devoted to the pursuit of knowledge, and mingling with the *literati* of the day, it is remarkable to see the effusions of missionary zeal—especially so in an age which, unlike our own, had scarcely any concern, and very few appliances, for evangelical effort in foreign lands. He printed and distributed at his own expense the Irish Bible. He also took a deep interest in promoting the gospel among the American Indians, in which labours John Eliot was so distinguished an agent;—and very interesting it is to turn over the letters of the missionary to his English friend and patron, and notice such passages as these: "Your constant care of and constant affection unto this Indian work (which the Lord hath, in great mercy to me, put under my hand, a weak and unworthy instrument therein) do greatly oblige my heart to honour you, and pray that it may be remembered of the Lord in that great day, when He will say, 'Come, ye blessed,' to all the sincere benefactors unto His people." "The poor praying Indians do thankfully acknowledge that (under God our heavenly Father, and under Jesus Christ our Redeemer, who redeemeth us out of all our troubles) you have been the means and instrument in His hand to save and deliver us." "When good works of pure charity are sown three-hundred-fold thick, and that by a living hand, Lord, what a reaping-time or harvest there will be. Sir, you are eminently mindful of that gospel charge—'Charge them that are rich in this world, that they be not high-minded, nor trust in uncertain riches, but in the living God, who giveth us richly all things to enjoy; that they do good, that they be rich in good works, ready to distribute, willing to communicate; laying up in store for themselves a good foundation against the time to come;'—a foundation, not of grace unto justification by way of merit, but a foundation of degrees of glorification, when God will, in free mercy, distribute His gifts of glory, according to our improvement of our talents in the exercise of grace. He that gained ten talents shall have ten cities."[1]

Boyle devoted to missionary work in New England £300 a year, during his life, and by his will bequeathed to the same object £100. Several people of distinction were nominally connected with the scheme, but he was its moving spring, its primary power, its very life. Its meetings, which he commonly attended, for transacting its affairs, were held at the house of a worthy London alderman named Ashurst, of pious memory; and those who there assembled constituted the first board of Protestant missions in this country. Boyle was also a director of the East India Company; and in a letter dated 1676 he urged upon his colleagues the duty of propagating Christianity in the East. He had, at his own cost, the Gospels and Acts translated into the language of the Malays, and undertook the whole expense of a Turkish New Testament, a burden of which the Company partly relieved him by undertaking half the cost.

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[1] Birch's *Life of Boyle*, Appendix, pp. ccv.–ccvii. These three passages are the commencement of three distinct letters.

The prospect of another state of existence most reasonably occupied a large space in the thoughts of this Christian philosopher. To be insensible or indifferent respecting the world to come, struck him as conduct utterly irrational. None of his chemical experiments, none of his investigations into the properties of matter, had ever disturbed his faith in the immortality of mind; and he lived year after year, with the assurance that a life unnumbered by the present revolutions of time would succeed the present. His meditations on the subject, in the light of the gospel, often rose to perfect rapture. If he dwelt, with a complacency natural to such a person, upon the intelligence, the intellectual improvement, and the immensely augmented knowledge of man in that future state of being, he also dwelt upon the perfect holiness, the likeness to God, and the fruition of the Divine favour, which, according to the promises of Scripture, will crown and glorify all the other bliss of heaven. "We shall be so taken up," he exclaims, "with the contemplation and fruition of that glorious object (in whose infinity all goods are included and dilated) that ages, numberless as the joys that beatific vision abounds with, will scarcely afford us leisure for a diversion to any other pleasures than those itself creates: which are so numerous and so entire, that we shall there desire nothing that we have not, except more tongues to sing more praises to Him; or, at least, a capacity to pay Him greater thanks for what we have. And even those desires, God's gracious acceptation will make, in being conceived, accomplished; for otherwise heaven's residents scarce know any other want than that of need to wish, the complete blessedness of their condition reducing them to a happy uselessness of wishes, by affording them a full prepossession of all the objects of desire. There time, like fire, having destroyed whatever it could prey on, shall at last die itself, and shall go out into eternity. There our felicity shall always be the same, yet ever new."

Supported by such views, this Christian philosopher fell asleep after a brief sickness, "the light of his mortal life going out for want of oil to feed the flame."

We have spoken of Boyle's extraordinary attachment to his sister, Lady Ranelagh. Truly it may be said of them, "They were lovely and pleasant in their lives, and in their death they were not divided." It is touching to learn that she died in London, two days before Christmas, 1691; and he died five days after.

JOHN LOCKE.

1632–1704.

METAPHYSICS is rather an equivocal word. If we understand by physical existence all kinds of existence, whether in the department of matter or the department of mind, then the word would simply point to what is *abstract* in human thought, and would properly be confined to speculations upon principles and laws, essences and qualities, with similar recondite subjects of reflection. But commonly the word *physics* is confined to what is *material* in the universe of being—to those forms of nature which appeal to the senses—and therefore *metaphysics* is a term usually applied to that realm of thought into which the mind steps on crossing the limits of material things. Metaphysics, then, may be extended to a vast number of abstract subjects, about which many persons feel immense curiosity and interest; but it will certainly comprise the study of the human mind itself—that mysterious instrument by which all philosophical inquiries are carried on. Metaphysics, in the first acceptation of the word, was a favourite study with the ancient Greek philosophers. They were fond of abstractions, hunting after original principles and foundations of existence, prying into the essences of things. Nor did they overlook metaphysics in the more limited meaning of the appellation; for "*know thyself*" was a dictum which pointed to a scientific as well as to a moral acquaintance with one's mind; and of Socrates it is said in the *Memorabilia,* "Man, and what related to man, were the only subjects on which he chose to employ his inquiries and his conversation."

Mental science, or the study of the mind with a view to estimate aright its capacities and faculties, would, of course, occupy more or less the attention of thoughtful men in subsequent ages. The schoolmen, in their diversified lucubrations, could not entirely overlook it; but it was not until after the restoration of learning in the fifteenth and sixteenth centuries that the mental constitution of human nature obtained the patient attention which it demands. Bacon, the author of all modern experimental science, may be regarded as really the author of it in relation to mind as well as matter; and in some of his profound hints on the subject, "nothing is more remarkable than the precise and just ideas they display of the proper aim of this science."[1] Hobbes, too, may be reckoned amongst our early mental philosophers, in the strictest sense of the title; for he had much to say in his *Leviathan,* and his *Human Nature,* about the "thoughts of man," and "the original of them all which we call sense," "the faculties of the mind—cognitive, imaginative, conceptive and motive;" nor did he fail to point out the association of ideas. Descartes is esteemed another founder of experimental philosophy in relation to mind; for his fundamental idea—"I think, therefore I am"—took him down at once into the depths of his own consciousness, to expatiate amidst the crowded thoughts which peopled it. Gassendi and Malebranche are also names conspicuous in this path of scientific study; but the highest place amongst the fathers of English intellectual philosophy belongs to John Locke, to whom we devote the present chapter. Hitherto our studies have been amongst those who have enlarged the boundaries of physical science; but we are by no means inclined to restrict the application of the term *science* to that department of philosophy. Mathematicians, astronomers, chemists and geologists, are acknowledged by everybody to be *scientific men*. They scientifically investigate the facts, and seek after the laws of matter. Why then should not metaphysicians—who instead of indulging in abstract reasonings about essences, scientifically investigate facts, and seek after laws of mind—be ranked amongst *scientific men?* We claim a foremost place in the temple of science for the statue of John Locke.

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[1] Dugald Stewart, Prel. Diss. to *Ency. Brit.*, p. 33.

John Locke was born at Wrington, near Bristol, on the 29th of August, 1632; and was, in due time, sent to Westminster School, where he acquired the elements of learning under the famous Dr. Busby. From Westminster he was elected, in 1651, a student in Christ Church, Oxford, then under Puritan rule; and there we picture him as a gownsman contemporary with John Howe and Philip Henry, Robert South and Christopher Wren, whilst Oliver Cromwell is Chancellor and Dr. Owen Vice-chancellor.

To Dr. Owen's well-known opinions on the subject of toleration, and to his example in carrying them out, as far as he could, perhaps Locke was in some measure indebted for similar convictions, the publication of which in more advanced life added so greatly to his fame.[1]

We find Locke amongst the poets contributing to the "*Musarum Oxoniensium ΕΛΑΙΟΦΟΡΙΑ*," in celebration of the victory over the Dutch in 1654; and we learn that he applied himself industriously to the study of Bacon and Descartes. He also paid attention to medicine, and, indeed, practically attempted a little in that department—more fortunate in this respect than some tyros in the healing art, for he is said to have saved the life of Lord Ashley, afterwards the well-known Earl of Shaftesbury, who continued till death his faithful friend. Though so successful in this attempt, and though applauded by the eminent Dr. Sydenham, who spoke of 'his penetrating and exact judgment,' as having few equals and scarce any superior, he was persuaded by his patient to divert his attention to other matters; and this probably was the turning-point of his life, for, instead of becoming a surgeon or physician, he became a philosopher, and devoted his life to scientific and theological literature. A story is told about him to this effect, that when at Lord Ashley's house he met with certain noblemen, esteemed wits of the day. They sat down to cards, and began to talk in no very edifying style, whereupon the young philosopher took out his pocket-book, and commenced scribbling. "What are you writing?" asked one of them, "My lord," he replied, "I am endeavouring to profit as far as I am able in your company;

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[1] This is the view taken by Locke's last and best biographer, Fox-Bourne: *Life of Locke*, i. p. 72.

for having waited with impatience for the honour of being in an assembly of the greatest geniuses of this age, and at last having obtained the good fortune, I thought I could not do better than write down your conversation; and indeed I have set down the substance of what hath been said for this hour or two." [1] The story goes on to say, that the wits felt rebuked as well as amused, and proceeded to talk with Locke in a way more accordant with his taste. The story is strange, but in those days plainness of speech was more common in fashionable society than it is now, and many anecdotes are told of clever reproofs administered not only without offence but with much advantage.

Locke followed the fortunes of his patron, Lord Shaftesbury, when, after an imprisonment in the Tower, the former was compelled to seek exile in Holland. England was then in a miserable condition. Charles II. was on the throne. Arbitrary power was in the ascendant. Little liberty remained for Englishmen, though in the Civil Wars they had shed their blood to win it; and hence, though the banks of that part of the Rhine could not compare with the banks of the Thames, or the scenery at Utrecht vie with that near Oxford, Locke in Holland was filled with delight. "The blessings," says Dugald Stewart, "which the people there enjoyed under a government peculiarly favourable to civil and religious liberty, amply compensated in his view for what their uninviting territory wanted in scenery and climate." [2]

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[1] Life prefixed to his *Works*, vol. i. p. xxii.
[2] Dissertation in *Ency. Brit.*

Whilst he was in Holland, a circumstance took place the record of which is a sad blot in the history of Oxford. Of course, at the time the authorities little thought of the fame which John Locke was destined to achieve; but they hated Locke's patron, the Earl of Shaftesbury, and could not but know that their late student, now at the Hague, was a zealous advocate of civil and religious liberty, then very hateful in the sight of the University. However, what they did originated not with them, but with people at court. A letter was sent to the Dean of Christ Church, Dr. Fell, then also Bishop of Oxford. It ran as follows: "My Lord,—The king being given to understand that one Mr. Locke, who belonged to the late Earl of Shaftesbury, that upon several occasions behaved himself very factiously to the Government, is a student of Christ Church; his majesty commands me to signify to your lordship that he would have him removed from being a student, and that in order thereunto your lordship should let him know the method of doing it."[1]

Dr. Fell replied, saying, that though he had fixed his eyes closely upon Locke, he had detected nothing improper in his conduct. "I believe," he said, "there is not in the world such a master of taciturnity and passion." But he was ready to summon the Christ Church student home, and if he did not come, to proceed against him. However, Sunderland did not wait for that issue, but on the 12th of November sent a royal command for Locke's expulsion. Four days afterward Dr. Fell writes, "I hold myself bound in duty to signify to your lordship that his majesty's command for the expulsion of Mr. Locke from the college is fully executed." Dr. Fell had not the spirit of Dr. Hough, who defied King James II. So the illustrious name of John Locke was blotted out of the rolls of Christ Church.[1]

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[1] Whitehall, Nov. 6, 1684.

It is stated that William Penn sought to procure a pardon for Locke, after the death of Charles, but Locke refused to accept pardon, when he was conscious of no crime.

In 1685, when the Duke of Monmouth was preparing for his unfortunate enterprise, the English envoy at the Hague was ordered to demand from the States General that Locke and others should be delivered up to the English Government; but he escaped arrest by means of concealment, and consoled himself by writing his *Letter on Toleration*. Before his return to England, he completed his *Essay concerning the Human Understanding*; but he did not publish it until he reached once more his native shores. This he did in 1688, when at the period of "the glorious Revolution" he came over from Holland in the same ship with the Princess of Orange. After the Government had changed, and William and Mary had ascended the throne, Locke might have been readmitted to Christ Church College as a supernumerary student; but that position he would not accept. After all, the University still disliked the philosopher and his doctrines; and, at a meeting of the Heads of Houses, soon after the publication of his

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[1] The correspondence has been frequently published. The story is told with much care in Fox-Bourne's *Life of Locke*, vol. i. p. 483.

Essay, it was proposed that the book should be condemned; and, at last, they agreed each to discourage in his own college the perusal of the new work. His two *Treatises on Government,* in which he opposed political theories sanctioned at Oxford, could not but increase the dislike felt there towards the advocate of liberty.

A great deal of mischief having been produced in this country, soon after the Revolution, by coin clipping, Locke pointed out the extent of the evil, of which many persons were unaware; and when the eyes of the public were opened on the subject, he published *Some Considerations of the Consequence of the Lowering of the Interest, and Raising the Value of Money*: in this publication he manifested an intimate acquaintance with subjects belonging to political economy, a science then in its infancy.

Locke was not a strong man: his lungs were affected by the polluted atmosphere of old London streets; and he sought purer air in the village of Fulham, where he visited the Earl of Peterborough, and at Oates in Essex, where he was entertained by Sir Francis Masham. In 1695 he accepted a Government appointment as Commissioner of Trade, an appointment he relinquished in 1700, on account of his inability to continue the discharge of his duties, though King William wished him to retain the post as a merited sinecure. In the pleasant retreat of the Mashams he finally took up his abode, and there spent the last fourteen or fifteen years of his life, "seldom coming to town; and during this agreeable retirement he applied himself to the study of the Scriptures."[1]

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[1] Life prefixed to his *Works*, vol. i. p. xxxviii.

Locke, as observed already, occupies a high place, indeed, the highest of all, amongst the fathers of modern mental science. He applied the Baconian principles of study to the investigation of the powers of the human mind, labouring to discover, not by deduction what the operations of the understanding ought to be, but by induction what they really are. He was eminently fitted for this important task by his extraordinary faculty for observation, which it has been thought was sharpened by his early medical occupation, close attention to the state of the body preparing for close attention to the state of the mind. Changes in the one are almost as delicate and subtle as changes in the other. His power of analysis was also very great. He could dissect thoughts, as well as muscles and arteries, and resolve complex ideas into their elementary constituents. Rarely has he been equalled in patient steadiness of attention to any object on which he fixed his thoughts; and where others could be soon wearied, or easily diverted, he with patience and perseverance pursued his task through the winding paths of a perplexing problem. His independence of judgment has been fully proved. No borrower from others, he thought for himself. He does not seem to have been a great reader, perhaps a truly eminent metaphysician rarely is so. From Bacon, no doubt, Locke had learned a good deal. Descartes he had perused, but chiefly in order to contest his principles. Hobbes has been thought by some to have been his great master; but Hobbes, according to Locke's own statement, he had scarcely studied: "I am not so well read," he remarks, "in Hobbes and Spinoza as to be able to say what were their opinions" on a particular subject then under discussion, and he immediately describes them as "those justly decried writers."[1] Locke's skill in illustration was almost unrivalled. No doubt in some respects this proved a hindrance more than a help, as it tempted him to trust to material analogies in a purely intellectual department; but nobody can fail to see in reading his works what a charm they impart to the driest discussions.

The origin of the *Essay on the Human Understanding* is thus delightfully depicted by the author in an epistle to the reader: "Were it fit to trouble thee with the history of this essay, I should tell thee, that five or six friends meeting at my chamber, and discoursing on a subject very remote from this, found themselves quickly at a stand, by the difficulties that rose on every side. After we had a while puzzled ourselves, without coming any nearer a resolution of those doubts which perplexed us, it came into my thoughts that we took a wrong course; and that before we set ourselves upon inquiries of that nature, it was necessary to examine our own abilities, and see what objects our understandings were, or were not, fitted to deal with. This I proposed to the company, who all readily assented; and thereupon it was agreed that this should be our first inquiry. Some hasty and undigested thoughts on a subject I had never before considered, which I set down against our next meeting, gave the first entrance into this discourse; which having been thus begun by chance, was continued by entreaty, written by incoherent parcels, and after long intervals of neglect, resumed again, as my humour or occasions permitted; and at last, in a retirement, where an attendance on my health gave me leisure, it was brought into that order thou now seest it." This simple picture of the origin of a great work is unfortunately not set by the author in any framework of pictorial facts, nor has he given us any date; but the last biographer of Locke informs us of a little debating society which met in the philosopher's chamber at Exeter House, and thinks that at one of its meetings, probably in the winter of 1670–1, the memorable conversation occurred.[1]

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[1] *Reply to the Bishop of Worcester.*

It is sagaciously remarked by Dugald Stewart: "On comparing the *Essay on the Human Understanding* with the foregoing account of its origin and progress, it is curious to observe that it is the fourth and last book alone which bears directly on the author's principal object. In this book it is further remarkable that there are few if any references to the preceding parts of the essay, insomuch that it might have been published separately without being less intelligible than it is. Hence, it seems not unreasonable to conjecture that it was the first part of the work in the order of composition, and that it contains those leading and fundamental thoughts which offered themselves to the author's mind, when he first began to reflect on the friendly conversation which gave rise to his philosophical inquiries."[2] There is much to recommend this view of the way in which the book was written; but we cannot help regarding the second and third books, which, like the fourth, relate strictly to the actual operations of the understanding, as bearing "directly on the author's principal object." At all events, the first book, which is devoted to a demolition of the Cartesian theory of innate ideas, cannot be regarded as containing the record of the earliest steps which the philosopher took when he broke ground in his new field of inquiry.

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[1] Fox-Bourne, vol. i. pp. 248–9.

[2] Prel. Diss., *Ency. Brit.*, p. 102.

An analysis of the well-known essay is here out of the question, so also is any critical examination of its peculiar principles; all that can or ought to be attempted is a slight enumeration of certain original observations which Locke contributed to the store of human knowledge.

He throws a great deal of light on the history of our sensations, pointing out in the eighth chapter of the second book, more distinctly than had ever been done before, the difference between the primary and secondary qualities of matter; that is, between the hardness, the extent, the form of bodies, on the one hand, and their temperature, their colour, and their sound, on the other. He traces the different ways in which primary and secondary qualities produce ideas in us, and also dwells upon the important distinction between sensation and perception, that is, between our original impressions of hardness and colour and certain acquired perceptions of objects which come afterwards; though it must be confessed that Locke fails to point out the difference between these two states of mind with the precision attained by subsequent metaphysicians. In his observations upon these points he recognises the connection between the external world of matter as an object of observation, and the internal world of mind as a subject of consciousness.

He has much to say about *reflection,* a word which, in his use of it, carries a very wide and deep meaning. He is by no means a philosophical sensationalist, ascribing the origin of all knowledge to the physical senses. With him the *power* of reflection is very strong and a rich source of human instruction. He speaks of it "as the other fountain from which experience furnishes the understanding with ideas," as connected with "perception, thinking, doubting, believing, reasoning, knowing, willing, and all the different actings of our own minds, which we being conscious of, and observing in ourselves, do from these receive into our understandings ideas as distinct as we do from bodies affecting our senses."[1] Here and elsewhere Locke clearly points out a power called reflection, to which he attributes the origin of knowledge not derived from sensation. And he also refers in several places to convictions in the mind of undoubted certainty which do not arise from mere sensations.[2] At the same time we must keep in view the fact that Locke nowhere brings out distinctly the idea of certain laws of belief being impressed upon the mind, so that they come into irresistible exercise when circumstances elicit their development.

Upon attention and memory he makes profound remarks. For want of attention, he observes, "ideas in the mind quickly fade, and often vanish quite out of the understanding, leaving no more footsteps or remaining characters of themselves than *shadows do flying over fields of corn.*" "The ideas, as well as children of our youth, die before us, and our minds represent to us those tombs to which we are approaching, where, though the brass and the marble remain, yet the *inscriptions are effaced by time, and the imagery moulders away.* The pictures drawn in our minds are laid in fading colours, and if not sometimes refreshed, vanish and disappear." "It may seem probable that the constitution of the body does sometimes influence the memory, since we oftentimes find a disease quite strip the mind of all its ideas, and the flames of a fever, in a few days *calcine all those images* to dust and confusion which seemed to be as lasting as if graved in marble."[1] The figures thus employed are exceedingly beautiful and poetical; but perhaps after all they rather serve to adorn the dry paths of mental science than to help the student in reaching satisfactory conclusions.

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[1] Book ii. chap. 1.

[2] See Stewart's Dissertation, p. 110 *et seq.* See also Rogers's *Essays,* ii. pp. 49–51.

The limitation yet certainty of human knowledge is one of Locke's favourite topics. He bids us stop when we are at the end of our tether, and sit down in a quiet ignorance of those things which, upon examination, are found to be beyond the reach of our capacities. "We shall not have much reason to complain of the narrowness of our minds, if we will but employ them about what may be of use to us, for of that they are very capable." "The candle that is set up within us shines bright enough for all our purposes." The discoveries we can make with this ought to satisfy us. "If we will disbelieve everything because we certainly cannot know all things, we shall do much-what as wisely as he who *would not use his legs, but sit still*

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[1] Book ii. chap. 10.

and perish because he had no wings to fly." "When we know our own strength, we shall the better know what to undertake with hopes of success." "It is of great use to the sailor to know the length of his line, though he cannot with it fathom all the depths of the ocean. It is well he knows that it is long enough to reach the bottom at such places as are necessary to direct his voyage, and caution him against running upon any shoals, that they may ruin him."[1] The practical sagacity here shown is worthy of all praise, and it furnishes one of the most powerful caveats ever entered against philosophical scepticism.

We cannot notice Locke's long disquisition upon *innate ideas,* except to say, it should be borne in mind throughout, that the author is dealing with a particular theory on the subject, perhaps the theory of Descartes, with, no doubt, reminiscences of Plato's famous cave, peopled with ideas. The pertinacity with which Locke keeps to his attack upon this hypothesis is really amusing. He is determined to drive out from every cave that he can enter all such "innate" inhabitants as he can discover lurking there. With the *ideas,* under the form in which he represents them, he is successful; but it is otherwise when he takes in hand *innate principles.* His antipathy to the whole herd of Cartesian imaginations makes him for the moment forgetful of certain things which he really believed and expresses in other parts of his essay. Though he objects to *innate principles* in words, he virtually admits innate *tendencies to belief* in much that he says on the subject of reflection, and in his positive assertion of satisfactory faith in truths which do not arise out of the sphere of our sensations; but, as remarked already, he nowhere clearly intimates his opinion, if he had formed any, respecting fundamental laws of human belief. Nor was Locke always consistent with himself. No one can carefully read his writings without noticing this; and the fragmentary way in which the essay was composed serves to account for a want of harmony between one part and another. In consequence of the diversified aspects of thought presented in the writings of this great thinker, a far-extended and long-continued controversy has been waged between metaphysicians as to the true place of Locke in point of philosophical doctrine. He is claimed by extreme French sensationalists, who would shut up all knowledge within the gates of the five senses. He is claimed by English positivists, who have a wonderful disinclination to step beyond the bounds of consciousness and sensation. On the other hand, he has been vindicated against both parties, and his doctrine of reflection has been so expounded as to include a recognition of fundamental laws of belief at the bottom of the human mind, which come into exercise when men begin to think and inquire. We have intimated in a few words our own impressions on this subject which is all that ought to be done in a work like this. At the same time, it is obvious to notice what a high place in the history of mental science a man must hold, and what a powerful influence he must exert, whose teaching has been the subject of so much learned discussion. "The criticism which has been expended on even the fundamental principles of his metaphysical theory would, as Judge Jeffreys said of the voluminous writings of Richard Baxter, 'fill a cart.'"[1] It will also be admitted on all hands, whatever opinion may be formed as to his treatment of *innate ideas,* that he has narrowly and sagaciously examined the facts of human consciousness, and has contributed a vast fund of observation on the subject for the instruction and delight of after ages.

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[1] Book i. Introduction.

Locke was a theologian as well as a philosopher. He was far indeed from treating religion as an irrational prejudice, or Christianity as an effete and worn-out system. Beyond the sphere of sensation he perceived the existence of a Divine eternal Being. Besides the knowledge to be derived from the external world of matter and the internal world of mind, he believed in Divine revelation as a source of infallible instruction; and upon the study of the Holy Scriptures he spent much of his time in devout "reflection," especially towards the close of life. In 1695 Locke anonymously published his *Reasonableness of Christianity.* The appeal was made, not to authority, tradition, or history, but to reason. The main object was to present the simplest and most rational form of religion. He concluded, from his study of the Gospels, that the primary requirement is, that men should believe Jesus to be the Messiah, the anointed and sent of God; that such a belief makes every one a Christian; and that upon it the superstructure of Christian piety must ever rest. Every reader of his work must see how hardly he labours to establish his point, how he repeats over and over again his fundamental principle. He objects to the enforcement of particular creeds, and he is opposed to all Church authority in reference to religion; though he speaks in general terms of salvation through Christ, he enters into no definition whatever of evangelical doctrines, indeed, such definitions he regards as foreign to his purpose.

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[1] Rogers's *Essays,* ii. p. 1.

Whilst teaching of this kind, with a continuous appeal to reason, runs through the larger part of the book, towards the close he enters upon the supernatural evidences of Christianity. Locke was an apostle of human reason as opposed to human authority, but he was no rationalist, in the sense of opposing revelation. Revelation he recognised as a form of supernatural wisdom, and in advocating it he appealed to supernatural wonders. He dwelt upon the miracles of Christ as conclusive proofs of His Messianic office—a topic which he also largely treated in a distinct essay. The book was attacked, not by infidels, but by believers, not by those who objected to Christianity, but by those who, attaching importance to certain truths passed over by Locke, thought that he presented an objectionable view of the gospel. He appeared to them to be a rationalist. Dr. Edwards, a clergyman of the Church of England, son of the famous Presbyterian who wrote the *Gangræna,* assailed the treatise with bitterness; and so great was its unpopularity in some quarters that a prelate who thought of it favourably candidly confessed: "If I should be known to think so, I should have my lawn sleeves torn from my shoulders." Foreign divines, however, hailed it with applause, especially Dutch friends of the Remonstrant school, Le Clerc and Limborch.

Locke's defects or mistakes relative to the objects of faith do not invalidate his main reasoning. His proofs of the truth and divinity of the gospel, drawn from the miracles of Jesus and from the necessity of an authoritative revelation of truth and morals, remain the same; and we would add, that of the devout faith of the author there can be no doubt, when we are assured that "he admired the wisdom and goodness of God in the method found out for the salvation of mankind; and when he thought upon it he could not forbear crying out, 'O the depth of the riches of the goodness and knowledge of God!'"

Locke, in his *Essay on the Human Understanding*, enters at large upon the question of the boundaries between reason and revelation,—a question involved in what he says on the reasonableness of Christianity. He asserts most plainly the principle that revelation cannot be admitted against the clear evidence of reason; but then, immediately afterwards, he adopts the distinction between things contrary to reason and things above reason, citing, as examples of the latter, the fall of angels and the resurrection of the dead. Anything not contrary to reason, he contends, is to be believed if taught by revelation. "Whatever proposition," he says, "is revealed, of whose truth our mind, by its natural faculties and notions, cannot judge, that is purely matter of faith, and above reason." Revelation in such matters "ought to be hearkened unto." Indeed, Locke goes so far as to say that in those things concerning which the mind "has but an uncertain evidence, and so is persuaded of their truth only upon probable grounds, which still admit a possibility of the contrary to be true, without doing violence to the certain evidence of its own knowledge, and overturning the principles of all reason: in such probable propositions, I say, an evident revelation ought to determine our assent, even against probability." Afterwards, dwelling upon the evils of enthusiasm, of which he had a great horror, he goes on to remark: "Reason must be our last judge and guide in everything;" which, strictly taken, would mean that no revelation can be a final authority; but he proceeds in the next sentence to tell us: "I do not mean that we must consult reason, and examine whether a proposition revealed from God can be made out by natural principles, and, if it cannot, that then we may reject it; but consult it we must, and by it examine whether it be a revelation from God or no. And if reason finds it to be revealed from God, reason then declares for it as much as for any other truth, and makes it one of her dictates."[1] This explanation restricts the office of reason to an inquiry into evidence as to whether what is thought to be revealed is really such, and leaves faith to rest ultimately, not in the apparent truth of a doctrine, but on the revelation making it known. To some, Locke, in all this, will not appear to have diverged from an orthodox treatment of evidences; to others he will seem to have vacillated a little, leaning now in a rationalistic, and then in an opposite direction. By none, we think, can he be fairly regarded as holding the modern doctrine of a verifying faculty,—a doctrine based on a philosophy different from his, and leading to conclusions at variance with his belief. Whatever might be Locke's abstract opinions, it is quite clear that he had no sympathy with the Socinian party, of whom he speaks as "positive and eager in their disputes;" forward to have their interpretations of Scripture received for authentic, though to others in several places they seem very much strained,—"impatient of contradiction, treating their opponents with disrespect and roughness." "May it not be suspected," he asks, "that this so visible a warmth in their present circumstances, and zeal for their orthodoxy, would (had they the power) work in them as it does in others? They, in their turn, would, I fear, be ready with their set of fundamentals, which they would be as forward to impose on others, as others have been to impose contrary fundamentals on them."[1]

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[1] These passages occur in the eighteenth and nineteenth chapters of the fourth book of the *Essay*.

Locke has sometimes been unjustly accused of scepticism, or at least of a tendency to scepticism in the effect of his philosophical teaching. No doubt his rejection of innate principles, when not qualified by a consideration of other parts of his essay, where his mind seems to lean another way, may produce upon some readers an injurious impression, and encourage them to adopt a scheme of positive philosophy inconsistent with belief in a spiritual world, and in the Divine truths of revelation. But it should be steadily kept in mind that Locke, when challenged on account of the relation of his premises to conclusions drawn by the sceptical writer Toland, expressly repudiated the connection, and declared his own sincere belief in those mysteries of the Christian faith which Toland had assailed. "Bishop Sanderson well points out the distinction between the statement *that a thing is* and the inquiry *how it is*; and it has been said that this

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[1] *Second Vindication.*

Locke overlooked, and left no room for a distinction between the inconceivable or mysterious and the absurd and contradictory;"[1] but the passage just quoted from the *Essay*, relative to faith above reason, really proceeds upon the reality of such a distinction,—the distinction between, on the one hand, believing *that a thing is*, without being able to explain *how it is*—in other words, believing what is felt to be above reason; and, on the other hand, admitting what is manifestly absurd and contradictory. Locke was prepared to believe in many facts, human and Divine, physical and spiritual, that involved very plainly much which, with all his reflective power, he could not explain or understand.

Locke wrote several strictly theological works. A useful *Commonplace to the Holy Bible*, which passes under the name of Dr. Dodd, has been ascribed to Locke, perhaps on grounds not satisfactory. Certainly we have from his pen paraphrases and notes on some of St. Paul's Epistles. These, after his death, were continued and completed by Pierce and Dr. Benson. This work is, in some parts, far from a satisfactory one, in the estimation of evangelical critics; but it indicates reverence for Divine revelation, and a deep nterest in the study of the holy oracles. In connection with his *Commentary*, it is proper to notice a paper which he wrote, entitled *Pacific Christians*, in which he gives the following admirable directions for reading the Word of God:

"If any one find any doctrinal parts of Scripture difficult to be understood, we recommend him, first, the study of the Scriptures in humility and singleness of heart; second, prayer to the Father of lights to enlighten him; third, obedience to what is already revealed to him, remembering that the practice of what we do know is the surest way to more knowledge, our infallible Guide having told us, 'If any man will do the will of Him that sent Me, he shall know of the doctrine' (John vii. 17); fourth, we leave him to the advice and assistance of those whom he thinks best able to instruct him, no men or society of men having any authority to impose their opinions or interpretations on any other the meanest Christian, since in matters of religion every man must know and believe and give an account for himself."[1]

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[1] *Letters, etc., of Dean Mansel*, pp. 306–316.

"In October, 1704, his disorder greatly increased. On the 27th of that month, Lady Masham, not finding him in his study as usual, went to his bedside, when he told her that the fatigue of getting up the day before had been too much for his strength, and that he never expected to rise again from his bed. He said that he had now finished his career in this world, and that in all probability he should not outlive the night, certainly not to be able to survive beyond the next day or two. After taking some refreshment, he said to those present that he wished them all happiness after he was gone. To Lady Masham, who remained with him, he said that he thanked God he had passed a happy life, but that now he found that all was vanity, and exhorted her to consider this world only as a preparation for a better state hereafter." ["I heartily thank God," he repeated, "for all His goodness and mercies to me, but above all for His redemption of me by Jesus Christ."] "He would not suffer her to sit up with him, saying that perhaps he might be able to sleep, but if any change should happen, he would send for her. Having no sleep in the night, he was taken out of bed and carried into his study, where he slept for some time in his chair. After waking, he desired to be dressed, and then heard Lady Masham read the Psalms, apparently with great attention, until, perceiving his end draw near, he stopped her, and expired a very few minutes afterwards, about three o'clock in the afternoon of the 28th of October, in his seventy-third year."[1]

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[1] King's *Life of Locke*, vol. ii. pp. 63-67.

"His death," said Lady Masham, his constant friend, "was, like his life, truly pious, yet natural, easy, and unaffected; nor can time, I think, ever produce a more eminent example of reason and religion than he was, living and dying."[2]

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[1] King's *Life of Locke*, ii. p. 46. The expression in brackets is added from the *Life* by Fox-Bourne, ii. p. 559.

[2] *Ibid.*, p. 560.

JOHN RAY.

1628–1705.

"On a fine summer day, in the year 1845, the village of Black Notley, near Braintree, in Essex, presented a spectacle of unusual animation. It was occasioned by the arrival of some distinguished men of science from the metropolis, members of the Linnean Society; while several of the county gentry, with their families, and notables from the neighbouring towns, poured in to welcome the strangers, and join in the object of their excursion. Prominent among the former were Edward Forbes, Ansted, and Bell, then the Professors of Botany, Geology, and Zoology at King's College; with Yarrell, and Bishop Stanley of Norwich, President of the Linnean Society. Proceeding to the churchyard, where 'the rude forefathers of the hamlet sleep,' they gathered round the tomb of one whose fame had gone far abroad—John Ray, the naturalist. His remains had then been lying in the grave nearly a century and a half. But a similar tribute of respect had previously been paid to his memory by other representatives of science, on the second centenary of his birth, the year 1828. A pyramidal monument, bearing a long Latin inscription, marks his resting-place, on the south side of the church, still in good preservation, having been frequently repaired. The edifice itself, an old plain tiled building, with a somewhat picturesque wooden spire, stands in a delightfully rural situation."[1]

The year before this gathering round the grave of Ray occurred, a society was formed, now well known as the Ray Society, for the publication of "new and carefully edited editions of rare books of established merit, unique MSS., and translations of works on zoology and botany, illustrated with fine engravings from the most recent discoveries;" and it would seem as if the visit to the neighbourhood of Braintree arose out of the recent establishment of this society.

Ray was born November 29, 1628, in the Essex village where he now lies buried, and was educated at Cambridge. Then after removing from Catherine Hall to Trinity College, he attained a Fellowship at the same time as did Isaac Barrow. In 1660 he was ordained deacon and priest, yet undertook no parochial cure; and when the Act of Uniformity was passed in 1662, not being able to subscribe, he was compelled to resign his Fellowship. He afterwards became closely associated with a gentleman named Willughby, distinguished by scientific attainments; Ray resided at his house, Middleton Hall, and of the sons of this gentleman, who died early, he took charge as guardian; one of the sons we find rose to the peerage as Baron Middleton. Ray spent a quiet life without holding any office, or undertaking any public duties, his time being occupied in intellectual pursuits which have made him celebrated in the annals of his country.

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[1] A description of this visit is given in the *Memorials of John Ray*, edited by Lankester, p. 53. The above extract is taken from a life of Ray in *The Sunday at Home* (1876).

Ray was a scholar. He became first Greek lecturer of his college, then mathematical lecturer, then humanity reader, and of the variety and curious nature of his learning, monuments remain in his *Collection of English Proverbs*; his *Collection of English Words not generally Used*; his *Dictionariolum seu Nomenclator Anglo-Latino-Græcum;* and his *Clavis Philosophiæ Naturalis, Aristotelica Cartesiana.*

Ray was a traveller. First we meet with him journeying in Wales, and England, and Scotland, just at the end of the Commonwealth, and the stirring times of the Restoration, when he must have witnessed many scenes of political excitement, and heard an immense deal of talk, both amongst Roundheads and Royalists. But the good man lived in a world of his own, and seems never to have troubled himself much with the public questions which agitated his fellow-countrymen.

His first journey was into Wales. Under the date, August 9, 1658, he writes: "I began my journey from Cambridge, and rode that night to Northampton, thirty-one miles, an old town, but indifferently handsome, the houses all built of timber, notwithstanding the plenty of stone dug in that country. It hath a very spacious market-place, and old castle demolished."

Natural more than architectural curiosities attracted his notice, and at Buxton he explored Poole's Hole, and began to speculate on the cause of the phenomenon.

"The bottom of this hole is all very uneven and slippery, and somewhat dangerous to walk in; the water therein dropping from the top, petrifies into a white crumbling stone, somewhat like alabaster; and wherever there is a drop of water distilling constantly from the top, there is under it a pillar of stone, which by degrees rises higher and higher, and will at last doubtless come to touch the very top. One of these pillars, more large and remarkable than the rest, they call the font, for its likeness; for they have all of them a cavity in the head containing a good quantity of water, into which the drops fall. The water *entire* petrifies not, but there be in it atoms of stone, dissolved and swimming, as do the parts of a metal dissolved in a convenient menstruum; with these, whether the water being overcharged doth precipitate or let go some, or whether by adhesion or similar attraction, some of them leave the water and stick to others, till at last they compound a great mass. For as common or rain water falling upon a stone doth continually carry away some insensible *ramenta*, or atoms of it, which probably are sustained by the water as a convenient menstruum; so here the water, being more than sated or impregnated with lapideous atoms falling upon a stone, doth continually let some go, which being of the same nature, adhere to the stone and augment its bulk."[1]

A second journey, begun July, 1661, took him northward to Barton-on-Humber. "We ferried over ourselves and our horses to Kingston-upon-Hull, five miles. At Hull we were received by soldiers, conducted to the main guard, and examined by one Captain Widdrington, who afterwards came to our inn to visit us." "The governor of the town, at our being there, was the Lord Bellasis." On visiting the Trinity House, the travellers saw a great whale-bone at the door, and the skeleton of a Greenlander seated in a canoe. The man had been picked up at sea in 1613, by Andrew Barker of Hull, in a half-famished state. He refused to take food, probably from fright, and soon died.

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[1] *Memorials of Ray: Itineraries,* p. 124.

The journey extended into the south of Scotland, about which are some curious notes.

"The Scots cannot endure to hear their country or countrymen spoken against. They have neither good bread, cheese, nor drink. They cannot make them, nor will they learn. Their butter is very indifferent, and one would wonder how they could contrive to make it so bad. They use much pottage made of colewort, which they call kail; sometimes broth of decorticated barley. The ordinary country houses are pitiful cots, built of stone, and covered with turves, having in them but one room; many of them no chimneys; the windows being small holes, and not glazed. In the most stately and fashionable houses in great towns, instead of ceiling they cover the chambers with fir-boards, nailed on the roof withinside. They have rarely any bellows or warming-pans. It is the manner in some places there to lay on but one sheet as large as two, turned up from the feet upwards.

"The ground in the valleys and plains bears good corn, but especially beer-barley or bigge, and oats, but rarely wheat and rye. We observed little or no fallow grounds in Scotland. Some laid ground we saw, which they manured with sea-wreck. The people seem to be very lazy, at least the men, and may be frequently seen to plow in their cloaks."

But, with approval, he says of Dumfries: "The people here frequent their churches much better than in England, and have their ministers in more esteem and veneration. They seem to perform their devotions with much alacrity. There are few or no Sectaries or Opinionists among them." [1]

On the 3rd of May, 1662, he set off on a two months' ride through Wales and Cornwall. He notes the antiquities as usual, but in the unhistorical way in which, until very recently, all such objects were commonly regarded. Plants he never seems to miss, and immediately connects them with others elsewhere. Rarely does he think it worth while to chronicle the impressions which fine scenery must have made upon him, for he invariably selects the loftiest and most romantic route. If he ever exaggerates, it is in describing the occurrence of his favourite plants. Thus, in Cornwall, he transfers to the whole country that which is certainly true of a considerable part, but not of the whole : "Nothing more common than *Osmunda regalis* (the great flowering fern, as it is called), about springs and rivulets in this country. Camomile grows in such plenty along the waysides, that one may scent it riding along." Near the Land's End he notes the existence of Dickon Gwyn, the only man that could speak the Cornish language. "Few of the children could speak Cornish, so that language is like, in a short time, to be quite lost :" a prophecy which came to pass within a century afterwards.

In 1663, Ray and his friend, Mr. Willughby, started on a tour abroad, and visited the Netherlands, France, Germany, Switzerland, Italy, Sicily, and Malta. Of these travels he wrote and published an account, entitled, *Observations, Topographical, Moral, and Physiological; with a Catalogue of Plants not Natives of England.* Respecting these travels, John Locke remarks, "Ray gives a brief yet ingenious description of everything he saw, and curiously lays before us anything that is rare; but in his account of mineral waters and of foreign plants, as one so understanding in these particulars, he outdoes anything that could be expected from other travellers." And on turning to the octavo volume of *Observations* we find the eulogium fully justified. Ray visited the Hague, Haarlem, Amsterdam, Utrecht, and other Dutch cities, noting well the natural productions of lands reclaimed from the waters of the ocean. At Basle he examined the plants growing on the banks of the Rhine; and at Zurich he was surprised at the colour of the lake; he gathered wild flowers at Constance, and at Lindau penetrated the neighbouring woods. At Munich he found aloe trees, and at Augsburg divers rare productions. At Nuremberg he was interested in the fortifications, but met with no great variety of plants; and he winds up his narrative thus far with a comparison between what he discovered in nature's treasures abroad and those he was familiar with at home. A number of Italian cities he visited, and described—particularly Venice, Milan, Pisa, Florence, and Rome. He had an eye for antiquities, for municipal institutions, and for manners and customs, but never overlooked the trees, the flowers, the birds, and the animals. "Plenty there is of wild fowl of the best sorts, and cheap enough; as partridge of two kinds, the common and red-legged partridge, woodcocks, snipes, duck and mallard, widgeon, teal, grey, green, and bastard plovers, curlews, and quails. Of small birds the greatest plenty that I have anywhere seen; as thrushes in winter time, an incredible number, blackbirds, store; larks, infinite."[1] The villas at Rome charmed him with their gardens of flowers, groves, and thickets of trees, cut hedges of cypress, laurel-bay, laurustinus, and many other evergreen plants. The fireflies of Italy excited in him, as in most travellers, immense interest; and he adds a curious notion, communicated to him by an English gentleman, "that those reputed meteors, called in Latin *ignes fatui*, and known in England by the conceited names of *Jack with a lantern* and *Will with a wisp*, are nothing else but swarms of these flying glow-worms."[2]

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[1] For all these extracts see *Itineraries*, in the *Memorials of Ray*, pp. 134, 153, 161.

Above everything else, John Ray was a naturalist; and the number and variety of his works on the favourite study of his life is truly surprising. He published a catalogue of the plants which grew in the neighbourhood of Cambridge, and added appendix after appendix. Then came his *Flora, seu de Florum Culturâ*, and his *Catalogus Plantarum Angliæ et Insularum adjacentium.* Some time after these followed *Catalogus Stirpium in exteris Regionibus* and *Methodus Plantarum Nova, brevitatis et perspicuitatis causa, synoptice in Tabulis exhibita.* These were heralds of a far grander work, which appeared in three goodly folios, *Historia Plantarum Generalis,* in which the author collects and arranges the different species of plants, 18,625 in number, discovered by botanists up to that time (1686-1704). The number known at present may be estimated at upwards of 150,000. For each of these large volumes the author received only £30, that is at the rate of about threepence per page!

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[1] *Observations Topographical,* etc., p. 310.
[2] *Ibid.*, p. 351.

To these botanical works others on zoology were added: *Synopsis Methodica Animalium, Quadrupedum et Serpentini Generis Vulgarium; Methodus Insectorum; Insectorum Historia, cui subjungitur Appendix de Scarabæis Britannicis;* and *Synopsis Methodica Avium et Piscium.* Thus Ray traversed nearly the whole domain of natural history, including not only plants and animals, but reptiles, insects, birds, and fishes, clothing his researches and discoveries in the pompous garb of the Latin tongue; not, however, it should be said, for the sake of idle display, but that the learned abroad, as well as the learned at home, might have easy access to his portly tomes and smaller works, Latin being the medium of communication in those days between English and foreign scholars, and none but scholars being then thought fit depositaries of nature's open secrets.

"In 1682 appeared his *Methodus Plantarum Nova,* 1 vol. 8vo, in which he proposed a new method of classifying plants, which, when altered and amended, as it subsequently was by himself at a later period, unquestionably formed the basis of that method which, under the name of the system of Jussieu, is generally received at the present day. In the formation of the principal groups into which he divided the vegetable kingdom, Ray derived his characters sometimes from the fruit, sometimes from the flower, and sometimes from other parts of the plant, as each in its turn seemed to offer the most strongly marked points of distinction. He first proposed the division of plants into dicotyledons and monocotyledons (*Methodus Plantarum*, 2nd edit. p. 2). He extended these divisions both to trees and herbs, stating that palms differ as much in this respect from other trees as grasses and lilies do from other herbs. Though he made these great discoveries and improvements, Ray obstinately continued in the old error of separating woody from herbaceous plants, or trees from herbs; and he held a long controversy with Rivinus on this point; he even went so far as to state that one of these divisions might be distinguished from the other by the presence of buds, which he says are only developed in woody plants. To him is due, however, the honour of the discovery of the true nature of buds, for he says that they are points at which new annual plants spring up from the old stock; but he stopped short in his discovery, in not extending them to herbaceous plants. In the first edition of the *Methodus* he formed twenty-five classes, taking the woody plants first, which he divided into trees and shrubs. In this system he fell into many errors, one of the most glaring of which, as he himself afterwards observed, was the separation of the different species of corn from the other grasses. He subsequently altered this, and revised the whole arrangement, making thirty-four groups instead of twenty-five, many of which are almost exactly the same as are adopted by botanists of the present day under the name of natural orders.

"His arrangement was too far in advance of the knowledge of the day; and the consequence was that it was little appreciated or adopted by his contemporaries and immediate successors, who, instead of improving the arrangement so ably sketched out, set about establishing others on artificial principles, all of which are rapidly sinking into oblivion, while the principles of Ray are tacitly admitted, and many of his fundamental divisions adopted in that beautiful, but still imperfect, natural system which has been formed by the labours of Jussieu, Brown, De Candolle, Lindley, and others.

"Ray made many researches in vegetable physiology. He published a very interesting paper in the *Philosophical Transactions* (No. 68), on the mode of ascent of the sap; and we find many observations on the structure and functions of plants scattered through his various works. In the first volume of the *Historia Plantarum* he collected together, under the title of *De Plantis in Genere,* all the principal discoveries which had been made on the structure and properties of plants by Cesalpin, Grew, Malpighi, and others, as well as by himself, so that he thus published by far the most complete introduction to botany that had then appeared."[1]

And this is worth notice, in connection with Ray's contributions to science, that he was not, like some, jealous about his fame, and anxious to keep to himself what he had discovered, lest others should claim the honour of originality. With regard to a certain discovery, he charmingly says to a friend: "I think I was the first who acquainted you with it; but that is best known to yourself, and I challenge it only by way of emulation, not envy; there being nothing more likely than that several persons, following the same studies, may many of them light upon one and the same observation. I am no Arcana-man, and methinks I would have everybody free and communicative, that wo may, if possible, considering the shortness of our lives, participate with posterity."[1] In return for all this, a succession of naturalists have delighted to do honour to John Ray's scientific worth. Gilbert White remarks: "Our countryman, the excellent Mr. Ray, is the only describer that conveys some precise idea in every term or word, maintaining his superiority over his followers and imitators, in spite of the advantages of fresh discoveries and modern information."[2] And again, Ray's works, according to Cuvier, "may be considered as the foundation of modern zoology, for naturalists are obliged to consult them every instant, for the purpose of clearing up the difficulties which they meet with in the works of Linnæus and his copyists. The particular distinction of his labours consists in an arrangement more clear, more determinate than those of any of his predecessors, and applied with more consistency and precision. His distribution of the classes of quadrupeds and birds has been followed by the English naturalists almost to our own days; and we find manifest traces of that he has adopted as to the latter class, in Linnæus, in Brisson, in Buffon, and in all other ornithologists."[3] Once more, Dr. Lankester, in the preface to his *Memorials of Ray*, for the Ray Society, says "that his arrangement, when carefully examined, will be found to contain the fundamental principle of the more recent scientific systems in natural history, and to have laid the foundations of the view of a natural classification of the vegetable kingdom put forward in later times." Finally Hallam, looking at the subject from a literary as well as scientific point of view, observes: "In the botanical works of Ray we find the natural family of plants better defined, the difference of complete and incomplete flowers more precise, and the grand division of monocotyledons and dicotyledons fully established. He gave much precision to the characteristics of many classes, and introduced several technical terms very useful for the perspicuity of botanical language; finally, he established many general principles of arrangement which have been since adopted. Ray's method of classification was principally by the fruit, though he admits its imperfections. 'In fact, his method,' says Pulteney, 'though he assumes the fruit as the foundation, is an elaborate attempt, for that time, to fix natural classes.'"[1]

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[1] C. Knight's *Biographical Dictionary*, art. "Ray."

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[1] *Correspondence of Ray*, p. 83.

[2] *Natural History of Selborne*, Letter xlv.

[3] By Cuvier, in *Biog. Univ.*

The most celebrated of all his works is the volume entitled, *The Wisdom of God manifested in the Works of the Creation*. It is strange that the book should sometimes be represented as striking out an original path of thought, when the author says in his preface: "I am sensible that this tractate may likely incur the censure of a superfluous piece, and myself the blame of giving my reader unnecessary trouble, there having been so much, so well written of this subject, by the most learned men of our time—Dr. Moore, Dr. Cudworth, Dr. Stillingfleet, late Bishop of Worcester; Dr. Parker, late of Oxon; and, to name no more, the

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[1] Hallam's *Int.*, iv. p. 579.

Honourable Robert Boyle." But if not original in its scope and design, the work is original in many of its observations, and generally as to the mode in which he treats his subject. He ranges over a wide field. In the first part he surveys the heavens, and the vast assemblage of the celestial bodies; the elements of fire, and air, and water; rivers and baths; vegetables or plants in all their variety; animals and birds, their habits and instincts; and insects and fishes, with the curiosities of their structure. The arrangement is often loose, involved, and confused, but the information is generally valuable and interesting. In the second part he dwells largely on anatomical subjects. The drift of the treatise is expressed by Ray in his *History of Plants;* indeed, he seems to have habitually united the naturalist with the theologian: "I have been mainly led to it for the illustration of the glory of God, since the indescribable variety of plants, together with their surpassing beauty, their wonderful order, and their immense importance, are among the most striking of all evidences and arguments as to the infinite power, wisdom, and goodness of the Supreme Artificer."

Though the author deals with the Aristotelian hypothesis that the world is eternal, and the Epicurean hypothesis that it is a fortuitous concourse of atoms; though he attacks what he conceives to be the Cartesian theory of natural law, and answers Cartesian objections to the argument drawn from final causes; the purport of the whole book, as the title indicates, is not so much to demonstrate the *existence* of God as to illustrate the wisdom of God; in other words, to point out numerous indications of intelligent design in the works of creation. The author appeals rather to the theist than the atheist. No fair objection lies against the essay, that it is incomplete as a proof *that there is a God.* Its purport is to show what wisdom and goodness there is in that glorious Being who has created the world, leaving the primary and fundamental fact that *there is* a Creator to be established on other grounds. No doubt the constitution of the human mind,—with tendencies of thought which, if not checked by sophistry, have in unnumbered instances inevitably led men to a belief in God, when the eye was opened to see what is *without,* and reflection was stimulated as to a consciousness of what is *within,*—lies at the basis of all valid evidence of the Divine existence. The fulcrum of the argument is *internal,* but to complete it the consideration of what is *external* must be added, and the two forms of reasoning, when put together, are of irresistible force. Having dwelt upon these preparatory grounds of proof, the mind is in a position to take up Ray's book with advantage, and to accompany the writer through pleasant paths of illustration touching the wisdom of Him who made all things.

Ray was not merely a student of natural religion. He had a profound reverence for revelation, and accepted the Gospel with all his heart, as the only sufficient remedy for the sins and sorrows of mankind. "Let us admire," he says, "the transcendent and unmerited goodness and love of God in doing such great things for us, as sending His Son into the world to take our nature upon Him, to suffer death for our sins, and to give us the great promise of eternal life; and let us endeavour in some measure to answer this love by suitable affections of the most ardent love and gratitude. That the eternal Son of God, equal with His Father, should so highly advance our nature as to unite it to the Divine in one Person, that so He might be qualified by the sacrifice of Himself to expiate our sins, to make an atonement for us, and to reconcile us unto God—the greatness of this love, together with the freeness and unmeritedness of it, there being not any, even the least, motion on our part to invite Him to it, is so matchless and stupendous that it challenges the highest degree of reciprocal affection and gratitude."[1]

Ray was evidently a devout man. Some prayers and meditations in his handwriting have been preserved. On the death of his friend Mr. Willughby we find him recording this supplication: "O Lord, Thou hast been pleased to make a sad breach among us, to deprive us of our most dear friend and relation, a person that was to some of us as the very light of our eyes, the joy of our hearts, the greatest outward comfort of our lives. Give us a sanctified use of this heavy affliction; and when our hearts are moved and affected with a sense of our loss, give us to consider our sins, and to spend some part of our tears in lamenting them. Give us to consider the vanity and uncertainty of our lives, and the emptiness and insufficiency of all things here below to satisfy the vast desires of our immortal souls."[2]

The following memorandum deserves to be introduced as a proof both of his filial piety and Christian devoutness: "March 15, 1678, departed this life, my most dear and honoured mother, Elizabeth Ray, in her house, on Dewlands, in the hall-chamber, about three of the clock in the afternoon, aged, as I suppose, seventy-eight; whose death, for some considerations, was a great wound to me. Yet have I good hope that her soul is received to the mercy of God, and her sins pardoned, through the merits and mediation of Jesus Christ, in whom she trusted, and whose servant she hath been from her youth up, sticking constantly to her profession, and never leaving the Church in these times of giddiness and distraction."[1]

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[1] Quoted in a life of Ray, *Sunday at Home* (1876).

[2] *Memorials*, p. 57. This is only part of the prayer.

The beginning of another prayer is here transcribed: "Most holy and ever-blessed Lord God, upon whom we have our constant and necessary dependence, and to whom, therefore, we owe all duty and service and obedience! We bless Thy holy name for all Thy mercies hitherto continued to us; for our health, and peace, and liberty; for all the necessary supports and comforts of this present life; but more especially for Thy spiritual mercies in things that concern a better life; for our redemption, by the precious blood of Thy Son; for Thy words and ordinances, the means of grace and salvation, the motions of Thy Holy Spirit, and assistances of Thy grace, and for Thy patience and long-suffering exercised towards us."[2]

His last letter was written to Sir Hans Sloane, on the 7th of January, 1704. It is a touching testimony of his value for human friendship whilst relying on Divine support: "Dear Sir, the best of friends,—

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[1] *Memorials*, p. 37.
[2] *Ibid.*, p. 58.

These are to take final leave of you as to this world. I look upon myself as a dying man. God requite your kindness expressed anyways towards me a hundredfold, bless you with confluence of all good things in this world, and eternal life and happiness hereafter, and grant us a happy meeting in heaven. I am, sir, eternally yours."[1]

Ray died on the 17th of January, 1705.

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[1] *Correspondence of John Ray*, p. 459.

GOTTFRIED W. LEIBNITZ.

1646–1716.

THE seventeenth century is wonderfully rich in scientific names. Before Bacon died Pascal was born: Boyle entered the world three years after Pascal: Ray came only one year later: after the lapse of three years Barrow followed: two years later Locke appeared: and in another decade Newton saw the light. He did not complete the entire circle of philosophers who shone as a constellation in that highly favoured age. When Newton was little more than an infant, and Locke and Barrow were boys at school, and Ray and Boyle were pursuing their university studies, and Pascal was beginning to make himself a name in Parisian society, there was a child born at Leipzig, son of a professor in the university there, who for versatility of endowments came to be distinguished above them all. In each of the three dissertations prefixed to the *Encyclopædia Britannica* the name of GOTTFRIED WILHELM LEIBNITZ is introduced with equal prominence, as illustrious in the annals of metaphysical, ethical, mathematical and physical science. "So various, indeed, are the phases of his character and genius, so numberless his accomplishments, that we may apply to him the well-known lines of Dryden, divested of the satire which was designed in their original application :

> 'A man so various that he seemed to be,
> Not one, but all mankind's epitome.'"

From first to last his story is full of marvels. He has painted his own portrait, and we see him plainly, in stature of middle height, with pale face, bright eyes, shrill voice, pronouncing with difficulty the German gutturals; graceful in his movements, and active in all his ways; often he did not go to bed, but after two or three hours' sleep in a chair would be hard at work again. He was self-taught, and could devote himself in immediate succession to varied employments. He read all sorts of books, and could talk on all sorts of subjects. Not that he was garrulous, for he informs us himself that he was not much addicted to conversation; when he began he went on fast enough, and could enjoy a joke; but he more frequently smiled than laughed. The noting down of so many minute particulars about himself is enough to show that egotism is to be added to the other qualities of this extraordinary man. As a boy he stumbled on two books, Livy, and the *Opus Chronologicum* of Calvisius. History and chronology thus, at the outset of his studies, challenged his attention; and though he knew little or nothing of Latin at the time, by poring over the contents of these tomes, skipping at first over what puzzled him, and then coming back to it when better informed, he with surprising rapidity mastered the contents without a dictionary. At first his preceptor did not know what to make of him, and strove to repress his presumptuous efforts; but at last he persuaded the father to open his library to this precocious son, who, ransacking the shelves, dived into Cicero, and Quintilian, and Seneca, and Pliny, and Herodotus, and Xenophon, and Plato, and the Greek and Latin fathers. He revelled in them, and he tells us, "before I was yet twelve years old I understood the Latin writers tolerably well, began to lisp Greek, and wrote verses with tolerable success."

We must be content with enumerating the branches of study which he pursued in mature life, together with the occupations which he filled and the intellectual exploits which he achieved.

First of all he devoted himself to the science of *jurisprudence,* being destined by his relatives to the profession of the law. "The knowledge previously acquired of history and philosophy," he says, "I now found however, of essential service. It enabled me readily to apprehend the theory and principles of the science of law; and not setting a very high value on that which it cost me so little to understand, I immediately entered upon the study of the practical part of my profession."[1]

When only twenty-two, he wrote an essay entitled, *Nova Methodus discendæ docendæque Jurisprudentiæ,* a bold undertaking indeed! An attempt to construct a new system of learning, and teaching the principles of government, startled the statesmen and scholars of Saxony, and made the young man the talk of all Germany. The Elector was deeply interested in the work, and it happened at the time that a learned jurist in his dominions was being employed upon a revision of Roman law, with a view to its adaptation to existing circumstances. Leibnitz was appointed his assistant, and soon became leader, publishing, in the same year 1668, a pamphlet entitled, *Ratio Corporis Juris reconcinnandi.* The title-page bore both names, but the contents were the product of one pen, that of the young student. Two years afterwards, we meet with him carrying to a distinguished statesman an introductory letter from Baron von Boineberg, with these words in it, "He is a young man from Leipzig, of four and twenty, doctor of laws, and learned beyond all credence." "The theory, and, what is to be wondered at, the practice also, of law is perfectly familiar to him."[1]

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[1] *Life of Leibnitz,* founded on a German work by J. Mackie, p. 31.

At twenty-four Leibnitz plunged into *politics.* The Electors of Mentz and Trèves, with the Duke of Lorraine, were busy in the summer of 1670, at Schwabach, consulting about the affairs of Western Germany. They discussed the formation of an alliance with England, Holland, and Sweden, against France. Leibnitz, with his friend Boineberg, was present, and ventured to oppose the policy of the magnates. He recommended that the German princes should form a league amongst themselves, and act independently; but when war had commenced, and the French were overrunning Lorraine, Leibnitz aimed at diverting the attention of Louis XIV. to the revival of an old scheme propounded in the fourteenth century, for an invasion of Egypt, and the establishment of a Christian empire under the shadow of the Pyramids—a renewal, in short, of the mediæval crusades. He even prepared a memorial to the Grand Monarque, bringing before him a plan for this African conquest, hoping thereby to turn away his thoughts from the subjugation of Holland. The MS. still exists in the royal library of Hanover. Next we find Leibnitz posting off to Paris to visit the French king with flattering credentials; "for the rest, all that is known is that his propositions were heard, considered, and rejected."[1] Leibnitz, for services rendered to the Elector, was, in 1696, appointed Privy Councillor of Justice, the highest judicial office in Saxony next to that of Vice-Chancellor. We meet with him afterwards seeking an interview with the Swedish monarch, Charles XII., and entering into conversation with Peter the Great; also acting as diplomatist at the court of Vienna, where he was received with honour by Prince Eugene.

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[1] *Life of Leibnitz,* p. 46.

Leibnitz was very active in promoting the interests of *education*. He formed a plan for the establishment of an Academy at Berlin, and visited that capital for the purpose in 1700, when he shared in festivities which were being held in connection with the nuptials of a Brandenburg prince. He drew up a charter for the institution, which was to promote the study of history, civil and ecclesiastical, the study of science in all its branches, and the application of the whole to practical ends. Agriculture, manufactures, commerce, the State and the Church, all were to be improved by the comprehensive scheme of this most inventive genius. Scarcely do we reach the close of this part of his story, when we are introduced to him again, whilst he is deeply engaged in advocating the commencement of a new school of medicine in Prussia. Next we are taken to Dresden, and there he is as busy as if he had nothing else to do, with another project for a Saxon Literary and Scientific Academy. Nor did popular education escape his attention, or fail to call forth his characteristic activity. Luther had done much for Germany by planting schools in as many parishes as possible; but now, after the lapse of a century and a half, they were in a state of decay, and needed much to be done for their revival and improvement. Leibnitz caught Luther's spirit in this respect, and felt the importance of carrying on and perfecting the Reformer's educational work; but circumstances were adverse, and war, the enemy of civilization, stood in the way of advancing culture. Franke's Orphan Asylum at Halle, a work of charity which has been the admiration of all ages since, called forth the philosopher's sympathy; and he even ventured to urge that an appeal should be made to the Czar of Russia to plant similar asylums here and there throughout his vast dominions. It is quite plain that Leibnitz was a philanthropist as well as a philosopher.

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[1] *Life of Leibnitz*, p. 61.

We now reach the notice of his pre-eminently special gift—his genius for *mathematics.* If he excelled in one study more than another, it was in this; and here, unfortunately, we come upon an unpleasant part of his history, for his brilliant mathematical discoveries brought him into competition with Sir Isaac Newton, and a dispute arose as to which of the two belongs an original secret—appearing in connection with the German philosopher as *the differential calculus,* in connection with the English as *the system of fluxions.* It was disputed first, whether the methods were essentially the same, and next, whether Leibnitz borrowed from Newton or Newton from Leibnitz. Of course we cannot enter into the controversy, and can only observe that it now seems to be acknowledged by the best critics that the two methods are essentially the same, and that neither of these illustrious men borrowed from the other. "To whatever point of perfection beyond Newton, Leibnitz may have carried his calculus, we need not hesitate to say that a decision as to whether the two methods be essentially the same or not may be regarded as a test of controversial candour or perverseness." "Whether Leibnitz was truly an independent inventor of this method—in principle identical with that of fluxions—is the only question, in our judgment, that really affects his fair fame; and that he was so is now, we may say, all but universally conceded."[1] At one time the idea that the same thought might occur to two minds, independently of each other, seemed perfectly inadmissible to the critics of Europe; and hence the contention relative to Descartes and Pascal already noticed; but now men are becoming wiser, and it no longer appears astonishing, certainly by no means incredible, that gifted men pursuing independent paths of inquiry, should reach two very similar results. Beyond all question, Leibnitz must be ranked amongst the greatest of mathematicians; and it is idle to contend as to whether he or his contemporary should bear the palm. In this case there are two palms; and let history acknowledge the freshness and beauty and immortality of each.

Leibnitz paid great attention to *practical* as well as *theoretical science.* He studied geology and mineralogy, not only in books but in mountains and mines. The Hartz district—that charmingly picturesque and romantic region, where scenery, architecture, poetry, and manners and customs combine to interest, instruct, and delight the foreign traveller—could not but have special attractions for a German philosopher, intent upon the investigation of different strata, and the appearance and substance of metals and minerals. There, accordingly, Leibnitz explored the recesses of the earth, entered the excavations of the miner, studied the treasures which lay embedded awaiting the processes of practical science, and handled and analysed the gold and the silver, the copper and the lead that have for eight hundred years been found together in the Hartz, within a smaller space perhaps than can be discovered with like varieties in any other region. He made an extensive collection of scientific observations practically unproved; and these results, with others afterwards obtained by travels in Northern Germany, Dalmatia, and Italy, he arranged in a work entitled *Prologäa*, which he wrote in 1691, but which was not published until after his decease. "To his praise be it said, that in an age when the theological sentiments prevailing even among Protestants presented a serious obstacle to the formation of correct views in geology, Leibnitz was the first person in Germany who made the various layers composing the earth's surface the foundation of a general geological theory respecting the origin and structure of our planet."[1] And it is a curious coincidence that as Locke turned his attention to the subject of English coinage, and as Newton was master of the English mint, so Leibnitz familiarised himself with the art of coining German money in connection with his study of mineralogy in German mines. In this, as in many other instances, it is remarkable how he turned the knowledge he acquired to practical account.

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[1] Rogers's *Essays*, vol. i. p. 198.

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[1] *Life of Leibnitz*, p. 122.

The acquisition of *languages* was one of his earliest achievements, and he seems to have been enlarging his knowledge as a linguist throughout the whole of his life; in addition to the ancient tongues, and five modern ones which he spoke fluently, he made acquaintance with the Russ not long before his death. The construction of some universal form of speech for conveying the knowledge collected by numerous races, and for remedying some inconveniences which took their rise at the building of the Tower of Babel, has been the dream of learned men at different times, and has given rise to ingenious, sometimes unintelligible, devices. Such an enterprise was the very thing to enlist the energies of the great Saxon philosopher, and we find him, from early life almost to the day of his death, employed at intervals upon the invention of what is called "a philosophical alphabet of thought." He had a notion that a language might be formed "which would express all kinds of abstract truth with the same precision and adequateness as the principles of arithmetic and algebra were denoted by figures and letters. For this purpose characters as expressive as those supposed to have been given to things by Adam, were to be invented, which should be the signs of those few primitive thoughts from which all others are more or less directly derived."[1] This idle scheme was to be extended to music, as well as to other subjects, so as to form "an arithmetic of the soul which knows not that it reckons;" to most people, surely, an altogether unintelligible collocation of words. Leibnitz, though he said the invention was easy, never seems to have got further than to broach the fancy; and so far he was surpassed—a rare thing, indeed, for him—by our own Bishop Wilkins, who not only wrote *An Essay towards a Real Character and a Philosophical Language*, but appended to it an *Alphabetical Dictionary*, wherein all English words, according to their various significations, are either referred to their places in the philosophical tables in the essay, or explained by such words as are in those tables. Wilkins also suggested a language that may "consist only of tunes and musical notes without any articulate sound."

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[1] *Life of Leibnitz,* p. 146.

To other employments Leibnitz added that of historian; and in this as in other ways, none but himself could be his parallel. He planned a history of Brunswick, to begin with the creation, not of man, but of the globe; and thus the historian was to bring to bear on his theme the geological information he had laboriously collected. The state of Germany being described long before Adam was thought of; and then the creation of man in its proper place, with the subsequent wanderings of the human family, until a Teutonic branch settled in the north of Europe, being all chronologically set forth, Brunswick was to appear in the annals of the world, and its fortunes were to be minutely rehearsed. But three volumes of introduction alone were written; and they did not touch even the geological commencement, for they were completely filled with a collection of authorities on the projected subject, bearing the unattractive title of *Scriptores Rerum Brunsvicensium Illustrationi Inservientes.*

Metaphysical philosophy, after all, is the domain in which Leibnitz has established the greatest and most enduring fame. The influence of his jurisprudence upon these studies is detected by his biographer, Dr. Guhzaner, who makes the reflections of Leibnitz on natural law and the constitution of society the starting-point of his speculations on the order and harmony of the universe. From the codes of civil government he rose to the principles of Divine rule; from human monarchies and states he ascended to the footstool of the throne of God. First framing a theory of the substance or essence of matter, he propounded his doctrine of *monads,* as being simple elements without parts, out of which bodies are compounded by aggregation. Sometimes they appear in his writings as metaphysical points, and then again as substantial forms, eluding the endeavours of most students to grasp the meaning of this original thinker. The monads are endowed with various properties, and are capable of change, and have the manifold and changeful phenomena of creation. And with the doctrine of monads he coupled the system of what he called pre-established harmony,—one of the strangest dreams which ever entered a scientific brain, for it supposed the independent action of mind on the one hand, and the independent action of matter on the other, and that though not influencing each other in any degree, they were so adjusted by Divine power, that the movements of the first should correspond with the movements of the second; thus, though the mind be not affected by the organs of vision, the image of an object on the retina of the eye coincides as to the time and manner of its appearance with the consciousness of the mind and the experience of perception. According to this cumbrous theory there is harmony amongst the monads, and harmony between the worlds of matter and mind; indeed, harmony prevails everywhere, and the whole universe is under the guidance of an infinite intellect and an all-powerful, righteous, and benevolent will.

This brings us to the theology of Leibnitz. His philosophy and theology interpenetrated each other, and so far from being a sceptic, his whole system of physical and metaphysical thought rested upon a basis of religious faith. Whatever opinion we may form of the method, we can but take one view of the spirit, purpose, and end of his philosophy. It was removed to the farthest possible distance from all atheistic ideas. Nor has it anywhere a pantheistic aspect: God and His works, though always connected in the theories of Leibnitz, are always distinguishable. The dominion is not confounded with the Ruler, the kingdom with the King.

No one can be more decided in affirming and maintaining the existence of God. He even attempts a mathematical demonstration of that doctrine;[1] but it is not so much a particular argument or an occasional statement which manifests his firm and unwavering theism, as the constant implication of Divine presence, Divine power, and Divine operation, through the subtle and varied phases of his comprehensive philosophy. His great theological work, the *Theodicée*, on the goodness of God, the liberty of man, and the origin of evil, published in 1712, is intended to meet and overturn the sceptical objections of Bayle to the doctrines of natural and revealed religion; and the aim of the author is to show that the world created by the Almighty is the best of all possible worlds: that a world of beings such as we are, endowed with freedom, could not consistently be preserved by any effective and irresistible method from the introduction of evil; that evil arises from the existence of imperfection, and that imperfection is the necessary condition of all created existence. To be perfect is to be Divine, to be human is to be imperfect. The origin of evil, the great puzzle of philosophers and theologians, thus exercises the thoughts of this subtle metaphysician; and we refer to what he says, not as a satisfactory solution of the problem, for such it is not, though we are inclined to think it moves in that direction, but as an indication of the religious spirit prevading his discussion of one of the most mysterious subjects of human inquiry. He will not attribute the origin of evil to the Author of all good. "It originates," he says, "in a necessary defect, in an inevitable privation, and therefore cannot be referred to the Divine Creator. For a Divine Cause is creative, it must be positive in action and influence; but sin, being a negative quality, has no dependent relation upon the Almighty, the All-wise, the All-good."[1] Of the freedom of man Leibnitz was convinced, and he also felt sure of the efficacy of Divine purposes and of the potent influence of Divine grace. To represent Leibnitz as a fatalist is wholly erroneous; his aim was to harmonize the unquestionable effect of motives on the human will with the full responsibility and the free action of mankind. On the theological side of the problem, the tenets of Leibnitz leaned in the direction of what is called moderate Calvinism—the union of faith in the efficacy of Divine grace with faith in the liberty and accountability of man.[1]

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[1] *Opera*, Edit. Berolini, 1840, p. 7.

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[1] *Theodicée, troisième partie. Opp.*, p. 577.

His manner of meeting mysteries is admirable. "The harmony which is found in all the rest of the universe, forms a strong presumption that we should also find it in the government of man, and generally in that of the entire spiritual world, if all were but known to us. It becomes us to judge of the works of God not less wisely than Socrates judged of those of Heraclitus, when he said, 'What I understand pleases me well; and I believe that the rest would please me no less, if I understood it.'" And again, "Attempts of reason, in which there is no necessity of resting upon certain hypotheses, serve to enable us to conceive that there may be a thousand ways of justifying the conduct of God; and that all the inconveniences we see, and all the difficulties it is possible to create, should not prevent our believing (when we cannot know by demonstration), as we have shown already, and as will appear hereafter, that there is nothing so high as the wisdom of God, nothing so just as His judgments, nothing so pure as His holiness, and nothing more immense than His goodness."[2]

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[1] *Op.*, pp. 513, 515, 714, 717.

[2] *Theodicée*, close of part 1. *Opera Philosophica*, p. 531.

On the same, or a similar subject, Leibnitz was once asked, whether he thought himself capable of leading men out of the ante-chamber of nature into the interior cabinet where lie hidden its profound secrets. He replied, that between the ante-chamber and the interior cabinet there is situated an *audience* room; and it is sufficient for mortals to remain there, without seeking to penetrate any further.[1]

On the respective boundaries of reason and faith he has much to say, and in doing so nowhere questions the authority of revelation.[2] It is true he does not quote Scripture in support of his views; but that is obviously because, in a dissertation like his, intended for the refutation of sceptics, appeals to the Bible for the settlement of the controversy would be irrelevant.

One word must be added respecting his endeavours to bring about some kind of union amongst the different denominations of Christendom. Ever since the Reformation, divines of a pacific and amiable tendency had mourned over the strifes of the theological world, and sighed for some scheme of comprehension which might prove a haven of rest. Melanchthon would have been glad to bring together the controversialists of his day. John Drury, less known than Melanchthon, spent his life in travelling over Europe, and making abortive attempts to establish union. Leibnitz cherished a similar desire, and took a great deal of trouble with princes and statesmen as well as divines to give it practical effect. But he left Europe very much as he found it. One sentiment he expressed in connection with his conciliatory schemes is well worth remembering, namely, that truth is more widely possessed than is generally supposed, the majority of sects being right in a great part of their affirmations, but wrong in a good many of their denials.[1]

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[1] Ueberweg, *Hist. of Philosophy*, ii. p. 102.
[2] *Opera Philosophica*, pp. 393, 403.

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[1] Ueberweg, *Hist. of Phil.*, ii. p. 102.

ISAAC NEWTON.

1642–1727.

As a literary philosopher, Bacon surpasses Newton; as an experimental philosopher, Newton surpasses Bacon. Newton's works contain nothing in point of style and illustration comparable to Bacon's essays; Bacon's works contain nothing in point of scientific discovery and mathematical calculation comparable to Newton's *Optics* and *Principia*.

NEWTON has been the great glory of the Royal Society; and the Royal Society is justly proud of its most illustrious ornament. He joined it in January, 1674, when he was excused the ordinary payment of a shilling a week, "on account of his low circumstances as he represented." In 1703 he was elected to the presidential chair, which he continued to occupy until his death, in 1727. Characteristic mementoes of him are preserved among the Royal Society's treasures. There is a solar dial made by the boy Isaac, when, instead of studying his grammar and learning Virgil and Horace, he was busy making windmills and water-clocks. We fancy we see him going along the road to Grantham on a market day with the old servant whom his mother sent to take care of him, and then stopping by the wayside to watch the motions of a water-wheel, reflecting upon the mechanical principles involved in the simplest contrivances. It is pleasant, with our knowledge of what he afterwards became, to sit down on the green bank by the river-side, and to speculate upon the ignorance of the old servant who accompanied him, and of the farmers they saluted by the way, as to the illustrious destiny which awaited the widow's son who lived in the manor house of Woolsthorpe. The reflecting telescope, preserved along with the dial, was made by Newton in his thirtieth year, and reminds us of the deep mathematical studies he was then pursuing at Cambridge. The autograph MS. of the *Principia,* also in the possession of the Royal Society, gives increased vividness to the picture of this extraordinary person in his study, solving mysterious problems, and suggesting others still more mysterious; and then the lock of silvery hair adds the last touch to fancy's picture,—like a stroke of the pencil which, when a portrait is nearly complete, gives life and expression to the whole.

Newton was portly, but not tall, his silvery locks were abundant without any baldness, and his eyes were sparkling and piercing, though perhaps they failed to indicate the profound genius which through them looked into the secrets of the universe. Wonderful humility blended with his intellectual greatness. To other men he seemed a spirit of higher rank, having almost superhuman faculties of mental vision, wont to soar into regions which the vulture's eye hath never seen; to himself he was but a boy playing with shells on the sea-shore, while the ocean lay undiscovered before him. Others were taken up with what Newton accomplished, Newton was taken up with what remained to be done.

So it is ever with the highest genius; the broader the range of view, the wider the horizon of mystery. He who understands more than others is conscious beyond others of what still remains to be understood.

Isaac Newton was born at Woolsthorpe, in Lincolnshire, on the 25th of December, 1642, one year after the death of Galileo, and just as England was being plunged into the confusion and miseries of civil war. Strange to say, as a lad, at first he was inattentive to study; but being struck a severe blow by a schoolfellow, he strangely retaliated by determining to get above him in the class, which he accomplished, and ere long became head of the school. His play hours were employed in mechanical contrivances, and a windmill in the course of erection on the Grantham road was an object of intense curiosity and a source of immense instruction. He soon had a windmill of his own, at the top of the house in which he lived. He had also a water-clock in his bedroom, and a mechanical carriage in the parlour, in which he could wheel himself. Paper kites and paper lanterns were his favourite toys. In the yard of the house, he traced on a wall the movements of the sun by means of fixed pins; the contrivance received the name of "Isaac's dial," and was a standard of time to the country people in the neighbourhood.

He entered Trinity College, Cambridge, the 5th of June, 1660, just as England was astir with Restoration festivities, and he soon devoted himself to mathematical studies. Euclid he took in at a glance, and afterwards proceeded to master Descartes' geometry. Isaac Barrow, then Lucasian Professor of Mathematics, became his friend and tutor; and the pupil repaid the master's kind attention by services rendered to him in connection with his optical lectures. In 1669 Newton succeeded Barrow in his professorship. He rose to eminence in the University, and in 1688 was chosen its representative in the Convention Parliament. In 1695 he was appointed Warden of the Mint, and was promoted to the Mastership in 1699. After his appointment to a Government office he left Cambridge to reside in London, and occupied for a time a house in Jermyn Street. From 1710 till two years before his death he lived close to Leicester Square. Next door to Orange Street Chapel there stands an old house which has seen a good many changes, and is identified as the abode of Sir Isaac, who had been knighted by Queen Anne in 1705. We visited it many years ago. The part of the house most intimately associated with his name is the little observatory perched on the roof. We were permitted to ascend into that spot, to see it deteriorated by its present use, for there we found a shoemaker busy at his toils. A glass cupola probably crowned the observatory in Newton's time, and evidently there was a window in each of the four walls. So here he looked out on the London of nearly a century and a half ago, hardly less crowded and smoky about the neighbourhood than now. Overhead, where Newton turned his eyes with most interest, we know it was just the same; the same beautiful stars shining out on a cold winter's night, the same planets sailing along the same blue ocean, the same moon throwing its light over the same old city. What observations, keen and searching, what calculations, intricate and profound, what speculations, far-reaching and sublime, must there have been, when one of the most gifted of mortals from that spot looked out upon the heavens, and in thought went forth on voyages of discovery into the distant regions of the universe! At the calm, still hour of midnight,—Sirius watching over the city of sleepers, Jupiter carrying his brilliant lamp along his ancient pathway, every one of the luminaries in the place appointed by Him who calleth them all by their names,—there stood the thoughtful man, with his reflecting telescope, occupied with thoughts which we common mortals in vain endeavour to conjecture.

The first department in the field which Newton explored with characteristic success was the study of optics. Philosophers were busy with inquiries into the nature of light. It had been long believed that every coloured ray is equally refracted when passing through a lens. Newton determined to analyse the prismatic hues. He made a hole in a window-shutter, and darkening the room, let in a portion of light, which he passed through a prism. The *white* sunbeam formed a circular image on the opposite wall; but the *prismatic colours* formed an image five times as long as it was broad. He was curious to know how this came to pass. Satisfied that the length of the image in the latter case did not arise from any irregularity in his glass, or from any differences in the incidence of light from different parts of the sun's disk, or from any curvature in the direction of the rays, he concluded, after thorough reflection, that light is not *homogeneous,* but that it consists of rays of diverse refrangibility. The red hue he saw was less refracted than the orange, the orange less refracted than the yellow, and the violet more than any of the rest. These important conclusions he applied in the construction of the first reflecting telescope ever used in the survey of the heavens, and an instrument is preserved in Trinity College Library bearing the inscription, "Invented by Sir Isaac Newton, and made with his own hands, 1671."

At the request of the Royal Society, he published in the *Transactions* an account of his optical discoveries, and proved that white light is a compound of seven prismatic colours. The method of demonstration is thus explained by Sir David Brewster: "It consisted in attempting to compound a white by mixing the coloured powders used by painters. He was aware that such colours, from their very nature, could not compose a pure white; but even this imperfection in the experiment he removed by an ingenious device. He accordingly mixed one part of *red lead*, four parts of *blue bise*, and a proper proportion of *orpiment* (yellow), and *verdigris* (green). This mixture was *dun*, like wood newly cut, or like the human skin. He now took one kind of the mixture, and rubbed it thickly on the floor of his room, where the sun shone upon it through the open casement, and beside it, in the shadow, he laid a piece of white paper of the same size. Then going from them to the distance of twelve or eighteen feet, so that he could not discern the unevenness of the surface of the powder, nor the little shadows let fall from the gritty particles thereof, the powder appeared intensely white, so as to transcend even the paper itself in whiteness. By adjusting the relative illuminations of the powders and the paper, he was able to make them both appear of the very same degree of whiteness. 'For,' says he, 'when I was trying this, a friend coming to visit me, I stopped him at the door, and before I told him what the colours were, or what I was doing, I asked him which of the two whites were the best, and wherein they differed; and after he had, at that distance, viewed them well, he answered, that they were both good whites, and that he could not say which was best, or wherein their colours differed.' Hence Newton inferred that perfect whiteness may be compounded of different colours." [1]

We cannot resist the temptation to quote the following passage from Brewster's *Life of Newton*, in reference to the natural fact illustrated in this discovery: "If the objects of the material world had been illuminated with white light, all the particles of which possessed the same degree of refrangibility, and were equally acted upon by the bodies on which they fall, *all nature would have shone with a leaden hue*, and all the combinations of external objects, and all the features of the human countenance, would have exhibited no other variety but that which they possess in a pencil-sketch or a China-ink drawing. The rainbow itself would have dwindled into a narrow arch of white light, the stars would have shone through a grey sky, and the mantle of a wintry twilight would have replaced the golden vesture of the rising and the setting sun. But He who has exhibited such matchless skill in the organization of material bodies, and such exquisite taste in the forms upon which they are modelled, has

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[1] Brewster's *Life of Sir I. Newton*, p. 41. Brewster is our chief authority throughout this sketch.

superadded that ethereal beauty which enhances their more permanent qualities, and presents them to us in the ever-varying colours of the spectrum. Without this the foliage of vegetable life might have filled the eye and fostered the fruit which it veils, but the youthful green of its spring would have been blended with the dying yellow of its autumn. Without this the diamond might have displayed to science the beauty of its forms, and yielded to the arts its adamantine virtues, but it would have ceased to shine in the chaplet of beauty and to sparkle in the diadem of princes. Without this the human countenance might have expressed all the sympathies of the heart, but the purple light of love would not have risen on the cheeks, nor the hectic flush been the herald of its decay."[1]

Everybody is familiar with the story of Newton's watching the apple fall from the tree. The tradition is fondly cherished on the spot where the philosopher is said to have been struck by the fact. The *law* by which the apple falls, not the *reason* which underlies the law, formed the subject of Newton's reflections, and led to the grandest of modern discoveries. The unknown cause of the apple's descent is the unknown cause of the planet's motion. That was the truth, simple and grand, which he brought to light and inculcated on the world. Newton reasoned thus: If gravitation extend from apples to the moon, it is perpetually drawing the moon to the earth by the momentary deflection of its curvilinear orbit from the direct line of the tangent; and if it decrease as the square of the distance increases, then, at the distance of sixty times the earth's radius, it ought to be the 3,600th part of the force of gravity near the earth's surface, where it makes bodies fall sixteen feet in one second. But, from the known period of the moon, and dimensions of her orbit, the actual deflection can be calculated, dependent on the value assigned to the earth's radius. Employing the value derived from the commonly received estimate of sixty miles to the degree, he found the resulting actual deflection considerably less than the theory required. He consequently desisted from the inquiry, and turned his attention to other subjects. The share which each of his predecessors in the attempt to solve this question could fairly claim has been much misapprehended. Horrox, Hooke, Huyghens, Halley, and Wren had made *approaches towards it*, which are detailed by the writer of "Sir Isaac Newton and his Contemporaries," in the *Edinburgh Review*. The error in Newton's first calculation arose from his taking the radius of the earth according to the received notion that a degree measured sixty miles, whereas Picard had determined it to be sixty-nine and a half miles. This was mentioned at a meeting of the Royal Society in 1682, at which Newton was present. "It immediately struck him that the value of the earth's radius was the erroneous element in his first calculation. With a feverish interest in this result, little imagined by those present, he hurried home, resumed his calculation with the new value, and having proceeded some way in it, was so overpowered by nervous agitation at its anticipated result, that he was unable to go on, and requested a friend to finish it for him, when it came out, *exactly establishing the inverse square* as the true measure of the moon's gravitation, and thus furnishing the key to the whole system." Hence proceeded Newton's immortal work, the *Principia*.

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[1] Brewster's *Life of Newton*, p. 72.

The fundamental principle of his system is *that every particle of matter is attracted by, or gravitates to, every other particle of matter, with a force inversely proportioned to the squares of their distances.*

This great law was established, not only by mathematical reasoning, but by accurate experiments. By means of these he was able to determine the *curve* in which a body moves when acted on by a force which varies inversely with the square of the distance; the action of sphere on sphere; the gravitation of the sun to the planets, of the planets to their satellites, and of the earth to the stone that falls upon it; the respective densities of the earth and other planets, and of the sun; the centrifugal force which combines with the centripetal or gravitating to preserve the balance of motion round the centre; the varying weight of bodies at the poles and at the equator; the true theory of the tides, as depending on the relative position of the earth and the moon; the explanation of the inequalities or variation of the moon's motion; the precession of the equinoctial through the circuit of the heavens in 25,920 years; and the form, position, and time of the motion of comets.

La Place observes that "Newton has well established the existence of the principle which he had the merit of discovering; but the development of its consequences and advantages has been the work of the successors of this great mathematician. The imperfection of the infinitesimal calculus, when first discovered, did not allow him completely to resolve the difficult problems which the theory of the universe offers; and he was oftentimes forced to give mere hints, which were always uncertain till confirmed by rigorous analysis. Notwithstanding these unavoidable defects, the importance and the generality of his discoveries respecting the system of the universe, and the most interesting points of natural philosophy, the great number of profound and original views, which have been the origin of the most brilliant discoveries of the mathematicians of the last century, which were all presented with much elegance, will ensure to the *Principia a lasting pre-eminence over all other productions of the human mind.*"

With reference to the *Principia,* Sir J. F. W. Herschel remarks: "In this great work Newton shows all the celestial motions known in his time to be consequences of the simple law that every particle of matter attracts every other particle in the universe with a force proportional to the product of their masses directly, and the square of their mutual distance inversely, and is itself attracted with an equal force. Setting out from this, he explains how an attraction arises between the great spherical masses of which our system consists, regulated by a law precisely similar in its expression; how the elliptic motions of planets about the sun, and of the satellites about their primaries, according to the exact rules inductively arrived at by Kepler, result as necessary consequences from the same general law of force; and how the orbits of comets themselves are only particular cases of planetary movements. Thence proceeding to cases of greater difficulty, he explains how the perplexing inequalities of the moon's motion result from the sun's disturbing action; how tides arise from the unequal attraction of the sun as well as of the moon on the earth and the ocean which surrounds it; and lastly, how the precession of the equinoxes is a necessary consequence of the same law."[1]

"From the time of the publication of the *Principia*, its mathematical doctrines formed regular parts of academical education; and before twenty years had elapsed its physical truths were communicated to the public in popular lectures, illustrated by experiments, and accommodated to the capacities of those who were not versed in mathematical knowledge. The Cartesian system, though it may have lingered for a while in the recesses of our universities, was soon overturned; and long before his death Newton enjoyed the high satisfaction of seeing his philosophy triumphant in his native land."[2]

What is called the Binomial Theorem is another of Newton's great triumphs in philosophy. It cannot be fully explained here; it suffices to say—any reader may comprehend the difference between a figure bounded by straight lines and angles, and a figure contained within a circle or any other curved line. The method of finding out the quantity of space in a figure of the former kind is obvious; and the ancient geometers had adopted a method of bringing a curve as near to a straight line as possible, by drawing straight lines from one point of the curve to another, until they had reached that which left the smallest quantity of space between the straight line and the curve, something like the shortest possible string across a bow. The space thus left between the straight line and the curve (as between the string and the bend of the bow) afforded the means of constructing triangles continually decreasing in size. The process of doing this was called the method of *exhaustion;* the principle on which it was done received the name of *infinite quantities;* and the quantity of space measured was called *the area of the curve.* Supposing quantities to be infinitely small, a line may be conceived of as an infinite number of points, a surface as an infinite number of lines, and a solid as an infinite number of surfaces. The application of "infinite quantities" to the measurement of curves, had engaged the attention of Roberval and Fermat, Hudde, Huyghens, Barrow, Wallis, and Kauffman, all of whom had made a near approach to the famous problem of squaring the circle. This was a branch of science which could not fail to interest the mind of Newton. By the *Binomial Theorem,* which he discovered in pursuing these studies, he had reached the *shortest* method of reducing curves to squares, and of solving some of the most difficult questions in mathematics.

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[1] *Discourse*, p. 272.

[2] Brewster's *Life of Newton*, p. 180.

In a paper, written after the *Principia, De Naturâ Acidorum* (On the Nature of Acids), he put forth his opinions on fire, flame, and elective attractions. Fire is a body so heated as to emit light copiously. Flame is a vapour heated so hot as to shine. The small particles of bodies act on each other at distances too minute to be detected by observation. By these attractive forces he explains the spontaneous melting of salt of tartar in the atmosphere; the necessity of great heat to distil water from salt of tartar; the tenacity with which sulphuric acid combines with water; the production of flame from cold fluids; fulminating powders, and many other chemical affinities; hot springs; volcanoes; fire-damp; the glittering appearance of several minerals; cohesion; capillary attraction; earthquakes; thunder and lightning; hurricanes; waterspouts; and landslips. On the same principle of elective attraction, he explains the varieties in the structure of hard, elastic, malleable, soft, fluid, and humid bodies, and the round figure of drops of fluid and of the globe.[1]

One often pictures the life of a philosopher as a life of hard labour, yet of complete quietude; but the biography of Sir Isaac Newton shows that controversy, often in angry mood, makes way into the peaceful bowers of scientific reflection, and sets one discoverer in very unpleasant antagonism to another. Claims to originality have been asserted and denied with all the passionate contention which we witness in the history of patents. Newton had two stout opponents in Leibnitz and Flamsteed. Much has been written as to his dispute with the latter. They had been intimate friends; but a coolness arose from some unexplained cause in 1696. Flamsteed had supplied Newton with lunar observations, and had mentioned the fact to his acquaintance, perhaps with some little vanity. The more renowned philosopher, on this account, rather querulously rebuked his fellow-labourer; and in the year 1704 very serious differences appeared between them. Flamsteed's catalogue of stars, a most valuable contribution to the cause of science, was placed in the hands of Newton and others for examination, in consequence of Prince George of Denmark having offered to bear the expense of printing it. According to the *ex parte* statement of Flamsteed, he received from this committee a good deal of vexatious treatment, after which they demanded that a copy of the catalogue, which Flamsteed still held in his possession, should be given up to them. This demand was complied with under protest; the catalogue being sealed up, with the understanding that so it should remain until the industrious student and observer should be able to complete it. In 1710, Flamsteed found the seal had been broken, and that the work was going through the press; a circumstance which greatly enraged him, he being by no means one of the meekest of men. Violent recriminations between the two illustrious astronomers immediately ensued, into the details of which we have neither time nor inclination to enter. We cannot acquit Newton of all blame in this affair. The breaking of the seal looks like an offence, and, as far as he participated in it, can scarcely be regarded otherwise than as leaving some shade (we cannot determine the depth of its hue) on the memory of our great philosopher. Still, his eminent virtues, which Sir D. Brewster has so laboriously illustrated and so eloquently eulogised, shine with a radiance too brilliant to be much obscured by this instance of culpability. Yet our reverence for no man's memory can justify us in shutting our eyes to his faults; and we should always feel that historical justice demands impartiality in the judgment of every question, however it may implicate the fame of distinguished individuals.

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[1] Here, and in some other portions of this article, we have made use of the life of Sir Isaac Newton in one of the monthly volumes of the Religious Tract Society.

Sir Isaac Newton was a firm believer in natural religion, that is to say, he felt a strong conviction that nature itself testified to the existence of an Almighty Creator. Here it will be most satisfactory to leave the philosopher to speak for himself.

In reference to the third book of his *Principia*, he says, in the first of his letters to Dr. Bentley,[1] "he had an eye upon such principles as might work with considering men for the belief of a Deity;" and in the same letter he remarks, in reference to the universe, "to make such a system with all its motions, required a cause which understood and compared together the quantities of matter in the several bodies of the sun and planets, and the gravitating powers resulting from thence; the several distances of the primary planets from the sun, and of the secondary ones from Saturn, Jupiter, and the earth, and the velocities with which those planets could revolve about those quantities of matter in the central bodies; and to compare and adjust all those things together in so great a variety of bodies, argues that cause to be not blind and fortuitous, but very well skilled in mechanics and geometry."

"It seems to me," Newton further observes in these letters, "that if the matter of our sun and planets, and all the matter of the universe, were evenly scattered throughout all the heavens, and every particle had an innate gravity towards all the rest, and the whole space throughout which this matter was scattered was but finite; the matter on the outside of this space would, by its gravity, tend towards all the matter on the inside, and by consequence fall down into the middle of the whole space, and there compose one great spherical mass. But if the matter was evenly disposed throughout an infinite space, it could never convene into one mass, but some of it would convene into one mass, and some into another, so as to make an infinite number of great masses, scattered at great distances from one to another throughout all that infinite space. And thus might the sun and fixed stars be formed, supposing the matter were of a lucid nature. But how the matter should divide itself into two sorts, and that part of it which is fit to compose a shining body should fall down into one mass and make a sun; and the rest, which is fit to compose an opaque body, should coalesce, not into one great body like the shining matter, but into many little ones; or if the sun at first were an opaque body like the planets, or the planets lucid bodies like the sun, how he alone should be changed into a shining body, whilst all they continue opaque, or all they be changed into opaque ones, whilst he remains unchanged,—I do not think more explicable by mere natural causes,—but am forced to ascribe it to the counsel and contrivance of a voluntary agent.

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[1] The originals of these letters, four in number, are preserved in Trinity College, and were printed in a pamphlet in 1756. Dr. Johnson reviewed them in the *Literary Magazine*, vol. i. p. 89. Johnson's *Works*, vol. ii. p. 343.

"I represented that the diurnal rotations of the planets could not be derived from gravity, but required a Divine arm to impress them. And though gravity might give the planets a motion of descent towards the sun, either directly, or with some little obliquity, yet the transverse motions by which they revolve in their several orbs, required the Divine arm to impress them according to the tangents of their orbs. I would now add, that the hypothesis of matter's being at first evenly spread through the heavens, is, in my opinion, inconsistent with the hypothesis of innate gravity, without a supernatural power to reconcile them, and therefore it infers a Deity. For if there be innate gravity, it is impossible now for the matter of the earth, and all the planets and stars, to fly up from them, and become evenly spread throughout all the heavens, without a supernatural power; and certainly that which can never be hereafter without a supernatural power, could never be heretofore without the same power."

The sublimest conclusion which Newton drew from his cautious and successful investigations of the laws of nature is put, with his characteristic humility, in the form of a query: "These things being rightly described, does it not appear from the phenomena that there is a Being incorporeal, living, intelligent, omnipresent, who, in infinite space (as it were in His sensory), sees the things themselves intimately, and thoroughly perceives them, and comprehends them wholly by their immediate presence to Himself? and of which things the images only, carried through the organs of sense into our little sensoriums, are there seen and beheld by that which in us perceives and thinks; and though every true step made in this philosophy brings us not immediately to the knowledge of the First Cause, yet it brings us nearer to it, and on that account is to be highly valued." The importance of such a query from such a man, and at the close of such demonstrations as he had given, will be best estimated by those who have attentively considered the poetical and mystic pantheism which has prevailed for ages in the east, and which not a few are attempting to substitute, in our own age and country, for the existence of the true and living God.

Newton's faith in revealed religion was quite as strong as his faith in natural religion. There is abundant proof that Newton was a professed believer of the gospel from his early years, that he was learned in the Scriptures, and that it was his familiar habit, his chosen occupation, to be much engaged in the reading of religious books. In the prime of life he was much employed in the profound study of Biblical subjects. To him the Bible was, in spiritual things, what the visible heavens and earth were in natural things—the witness for God, the manifestation of His wisdom, the display of His power, the assertion of His righteous government, and the revelation of His saving grace. With the same humbleness of mind with which he laid aside the opinions of speculative philosophy, that he might observe the works of God as He had made them and sustained them, and, by means of them, declared Himself to man, and accomplished His benevolent designs—so Newton came to the study of the Scriptures, bent on knowing what they *are*, what they *contain*, what they *mean*, and with *what purposes* the holy men of God were moved by the Spirit to write them for the instruction of mankind. His principal theological work shows how fully he believed in the inspiration of Scripture. Prophecy, to many scientific men a repellent rather than attractive object of study, seems to have laid a strong hold on his inquisitive mind; and we have the result in his *Observations on the Prophecies of Daniel and the Apocalypse of St. John*. In the first part, on Daniel, Newton gives a brief account of the Old Testament writings, especially of the book in question, and the place which it occupies among the prophetical records. He then explains the figurative language of prophecy. Having done this, he applies his explanations to the great image of gold, silver, brass, and iron, as indicating the empires of the Babylonians, the Persians, the Greeks, and the Romans; "the stone cut out of the mountain without hands," representing a new kingdom, which was to arise after the other four, to conquer all nations, and last till the end of time. He explains the vision of the four beasts as pointing to the same four kingdoms under another aspect:—the united kingdom of Babylon and Media, by which the Assyrian power was subdued, being represented by a lion with eagle's wings; the Persian empire, together with the kingdoms of Sardis, Babylon, and Egypt, appearing as a bear with "three ribs in the mouth of it, within the teeth of it;" the Greek empire, with the kingdoms of Cassander, Lysimachus, Ptolemy, Seleucus, being symbolized by a four-headed and a four-winged leopard; and the Roman empire and its ten fragmentary kingdoms, after the fall of its universal power, being typified by the fourth beast, dreadful and terrible and strong exceedingly, with ten horns and iron teeth. Thus Newton proceeds, and then identifies "the little horn" as the Papal Church. After noticing the predictions as to the Medes and Persians, he regards the last prophecy as a commentary on the previous vision, and points out "the king doing his own will," as the Greek or Eastern empire after its separation from the West. Whatever may be thought of all this, it proves, at least, Newton's thorough belief in the Divine origin of the Old Testament; moreover, his comments and calculations respecting the seventy weeks show how he regarded the prophecy of the *times* of the Messiah as evidences of the inspiration of the book of Daniel.

In that part of the work which treats of the Apocalypse, he expresses his opinion that this book was written at an earlier period than the Epistles of Peter and the Epistle to the Hebrews; and, having explained the scenery of the visions in relation to the temple worship at Jerusalem, he traces the connexion of the Apocalypse with the book of Daniel, and then proceeds to illustrate his views of this closing prophecy. On all these prophecies he makes the observation, that they were not given to gratify our curiosity about the future, but to afford convincing proofs that the world is governed by Providence; and he declares that his own design is to follow in the steps of previous writers, of whom, he says, "there is scarce one of note who hath not made some discovery worth knowing."

To weaken the force of Newton's writings on theological subjects, attempts have been made to show that they belong to the latter part of his life, when his mind had become enfeebled by disease. Between 1712 and 1719 is the date assigned to them; but Sir David Brewster has satisfactorily shown that previous to 1692 Newton was known as an "excellent divine," and that his work on the prophecies was commenced—or, at least, the researches preparatory to it—before 1691, when the author was in his forty-ninth year, and in the full vigour of his intellect, which, indeed, never seems to have been at all seriously impaired.[1]

We may add that Newton wrote a book entitled, *An*

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[1] Brewster's *Life of Newton*, pp. 244–248.

Historical Account of Two Notable Corruptions of Scripture; which has led some critics to call in question his orthodoxy. The passages are 1 John v. 7, and 1 Tim. iii. 16. The first of these contains the well-known words, "For there are three that bear record in heaven, the Father, the Word, and the Holy Ghost." Scarcely any biblical scholar in the present day would attempt to defend the reading as a genuine portion of the original text; and therefore, in rejecting it, Newton did but anticipate the common result of modern scholarship. The second passage is the sentence, "Great is the mystery of godliness: God was manifest in the flesh." This, though still contended for as genuine by many, is given up by some orthodox theologians, so that Sir Isaac stands supported, to some extent, by unimpeachable critics. But the only point here requiring notice is, that he did not make his opinion of the corruptness of the received text in these two instances any argument against the doctrine of our Lord's Divinity—plainly taught in other parts of the sacred volume. He says, with regard to the second of these sentences: "In the eastern nations, and for a long time in the western, the faith subsisted without this text; and it is rather a danger to religion than an advantage to make it now lean upon a bruised reed. There cannot be better service done to the truth than to purge it of things spurious. It is no article of faith, no point of discipline, nothing but a criticism concerning a text of Scripture, which I am going to write about." We further know that Newton was offended at Whiston's claiming him as an Arian.[1]

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[1] Brewster's *Life of Newton*, p. 255.

And let it not for one moment be supposed that in all or in any of these matters Newton was a mere theological dogmatist. There are men who write with zeal on points of divinity, some on the orthodox, some on the heterodox side, who are alike destitute of the moral spirit of the gospel. Far otherwise was it with Isaac Newton. "It is said of the greatest man that Cambridge has ever produced, it is said by those who knew Sir Isaac Newton well, that his soul was '*the whitest*,' that is, the most *candid*, the most unworldly, they had ever known—even 'the religion unspotted from the world, pure and undefiled.'"[1] And in connexion with this extract it is interesting to notice that Warburton, in one of his sermons, speaks of "*candid light*" in reference to the combined hues in the full sunbeam—the very fact on which our philosopher shed his own special illumination. His life, then, is seen to afford an instance of moral "candid light," of which his scientific doctrine is an emblem. The moral light of Christianity shone *in* him and *through* him—refracted and broken, no doubt, by human imperfections, still it contained those prismatic virtues which go to make up the grand moral lustre of the gospel: to add another figurative expression of the same class, he wore "the white flower of a blameless life."

Newton spent his last days in Kensington. "It was Sunday night," says his nephew, "the 7th of March, 1725, at Kensington, with Sir Isaac Newton in his lodgings, just after he was come out of a fit of the gout, which he had in both of his feet for the first time, in the eighty-third year of his age. He was better after it, and had his health clearer and memory stronger than I had known them for some years." A year later, the same diarist says: "April 15, 1726. I passed the whole day with Sir Isaac Newton, at his lodgings, Orbell's Buildings, Kensington, which was the last time I saw him." The house was lately in existence, situated in what is called Bullingham Place, retaining, when we visited it, a mansion-like aspect, with a large garden and tall trees. There he died, the 20th of March, 1727, having on the previous day been able to read the newspaper, and to hold a long conversation with Dr. Mead.

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[1] Stanley's *Funeral Sermon for Sedgwick.*

His body was laid in state in the Jerusalem Chamber, and then buried in Westminster Abbey.

At the funeral, his relative, Sir Michael Newton, Knight of the Bath, was chief mourner. He was followed by other relatives, and some of the most distinguished personal friends of the departed. The pall-bearers, Fellows of the Royal Society, were the Lord High Chancellor, the Duke of Roxburgh, the Duke of Montrose, the Earl of Pembroke, the Earl of Sussex, and the Earl of Macclesfield. The Bishop of Rochester performed the service, assisted by a prebendary and the choir of the Abbey. In the most conspicuous part of that great temple stands his monument, erected in 1731, at the cost of £500, by his relatives. The following is a translation of the Latin inscription:

Here lies
Sir Isaac Newton, Knight,
who, by a vigour of mind almost supernatural,
first demonstrated
the motions and figures of the planets,
the paths of comets, and the tides of the ocean.

He diligently investigated
the different refrangibilities of the rays of light,
and the properties of colours to which they give rise.
An assiduous, sagacious, and faithful interpreter
of nature, antiquity, and the Holy Scriptures,
he asserted in his philosophy the majesty of God,
and exhibited in his conduct the simplicity of the gospel.
Let mortals congratulate themselves
that there has existed such, and so great
An Ornament of the Human Race.
Born, 25th Dec., 1642; died, 20th March, 1727.

This epitaph combines the two views which we have attempted to bring out in this brief sketch. He was a philosopher and a Christian. The fact may be so exhibited as to do more honour to philosophy than to Christianity; as if he had conferred some credit on the gospel by embracing and maintaining it. The disparity between the Divine and the human is so infinitely great that we should never forget it; and, shrinking from the semblance of any representation which should make Newton appear as a *patron* of the Gospel, we would describe him as he really was, and as we are sure he would have wished to be represented,—a humble disciple of Jesus Christ, in whom he recognised all the treasures of wisdom and knowledge, and at whose feet he wished to sit as a little child.

GEORGES CUVIER.

1769–1832.

GEORGES CHRÉTIEN LEOPOLD DAGOBERT CUVIER was born at Montbéliard, a place of manufacturing industry about forty miles from Besançon, now within the French dominions, then a little principality pertaining to the Duke of Wurtemberg. Young Cuvier was remarkable for his intelligence and precocity; and an incident in his boyish days indicated the bent of his genius, and the sphere of knowledge and discovery in which as a man he was destined to excel. He found one day, amongst his father's books, Buffon's work on natural history, and it suggested the idea of copying and colouring the plates, after he had carefully studied the text. The contents formed his chief reading for many years.

The relatives of Cuvier were poor. His father was a pensioned officer in a Swiss regiment in the service of France. His mother was an affectionate, godly, wise woman. To her early lessons in Latin, geography, and drawing, and to her communications of religion, he always acknowledged himself much indebted. He went to the public gymnasium at the age of ten, and remained there for four years, bearing off prizes for learning and athletics. Through the patronage of a Wurtemberg princess, he was sent to the university of Stuttgart, where he pursued a course of scientific study, particularly in the division relating to natural history. There he acquitted himself with distinction, not only in that special department, but also in the most sacred branch of learning. "The young Cuvier," said his examiners, "has shown just notions of Christianity well adapted to his years," and "considerable skill" in reading the Greek Testament.[1]

Circumstances compelled him in early life to do something towards earning a livelihood, and in 1794 he became tutor in a French Protestant family living in the castle of Fiquainville, near Fécamp. In that little Norman fishing town he found much to gratify his curiosity: and he might often be seen scouring the country after birds, butterflies, and other insects; or prying into nooks and corners on the shore, after shell-fish and other marine productions; whilst the treasures of the boundless sea inspired wonder, with a longing to explore its depths, and to become acquainted with the forms of life hidden under its waters.

He appears to have continued in the family of Count d'Hericy for nearly seven years. He was introduced to the *savans* of Paris by his researches, and accepted an invitation to remove thither in 1795. He reached the French metropolis just after the horrors of the Revolution. Papers written by him already on his favourite subject had brought him into notice; and he found congenial employment in the Jardin des Plantes—the home of his after studies, and the sphere of his scientific exploits. There he worked and lectured, and obtained the office of assistant to the aged professor of comparative anatomy. In the year of his appointment, he made a mark on the study which he rendered so famous, by a Memoir on the Meganolix, a fossil animal known by a few of its bones, and which, contrary to received opinion, he boldly proved to have been a gigantic sloth. This was the first of those able comparisons of the fossil with the present world which revolutionized geology, extended comparative anatomy, and absolutely created the science of palæontology. He was also appointed to a professorship of natural philosophy in the College of France; then he rose, step by step, under the favour and patronage of Napoleon, who made him an inspector-general of schools; secretary to the French Institute; councillor of the new Imperial University; and organizer of reformed colleges in Italy, Holland, and Germany, after the vast extension of the empire. Even at Rome he was thus employed in 1813; and though a Protestant, he there won the good opinion of the authorities. The conquest and banishment of the great ruler of France did not spoil the fortunes of Cuvier; for, after the restoration of Louis XVIII., he was confirmed by that monarch in the office of state councillor, to which he had been appointed by the emperor, and in 1819 he was made a baron of France.

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[1] Mrs. Lees' *Memoirs of Cuvier*, p. 271.

Just before this he visited England, and was received with the highest honours. Another visit followed in 1830. An amusing circumstance occurred on one of these occasions, indicative of his wide-spread fame amidst the lower as well as the upper classes of society.

When in London, owing to the absence of his valet, he sent for a barber to shave him. When the operation was finished, he offered payment. "I am too much honoured," replied the Gascon—for such the operator happened to be, "by having shaved the greatest man of the age, to accept any recompense." M. Cuvier allowed him the honour to the full extent, and engaged him to perform the function repeatedly, for which, at length, he was willing to pocket payment.[1]

Cuvier's life must have been most laborious. The same year in which he was made baron he became president of the Committee of the Interior; and the numerous and various affairs which there passed under his review, and required his examination, were perfectly wonderful: together with his scientific employments, they seem more than any mortal man could undertake. But by economy of time and distribution of labour, concentration of thought, retentiveness of memory, and a profound knowledge of principles in every department, he acquitted himself in a manner which secured universal admiration.

Charles x., of France, and the King of Wurtemberg, vied with each other in the honours they conferred on Cuvier; and on the accession of Louis Philippe to the French throne the new sovereign continued the favours shown by his predecessor, and in 1832 made the baron a French peer. But his end was now drawing nigh. "Gentlemen," he said one day to his hearers, in opening a new course of lectures, "these will be the objects of our future investigations, if time, health, and strength shall be given to me to continue and finish them with you." But an overwrought brain the very next day produced paralysis, and the distinguished statesman and philosopher died at the age of sixty-three, on the 13th of May, 1832.

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[1] Lees' *Life of Cuvier*, p. 314.

His three great scientific works include :—

1. *Le Règne Animal, distribué d'après son Organisation, pour servir de Base à l'Histoire Naturelle des Animaux, et d'Introduction à l'Anatomie Comparée* (Paris, 1816), in fifteen royal octavo volumes, superbly printed, and beautifully illustrated.

Down to the time of Cuvier, the classification of animal life had been most imperfect and unsatisfactory. The basis adopted by Ray, as already noticed, was open to criticism. Comparative anatomy, rising into importance during the eighteenth century, continued through that period in a state of infancy. Linnæus and Buffon rendered valuable service; but all former students in this branch of science were surpassed by Cuvier. A curious anecdote is recorded of the ignorance of natural objects which continued even after the opening of the present century. When the committee of the French Academy were employed in preparing the well-known Academy dictionary, Cuvier came one day into the room where they were holding a session. "Glad to see you, M. Cuvier," said one of the forty; "we have just finished a definition which we think quite satisfactory, but on which we should like to have your opinion. We have been defining the word 'crab,' and explained it thus: 'Crab, a small red fish, which walks backwards.'" "Perfect, gentlemen," said Cuvier; "only, if you will give me leave, I will make one small observation in natural history. The crab is not a fish, it is not red, and it does not walk backwards. With these exceptions, your definition is excellent."

"Cuvier was the first to give a really philosophical view of the animal world in reference to the plan on which each animal is constructed. There are, he says, four such plans,—four forms on which animals appear to have been modelled, and of which the ulterior divisions, with whatever titles naturalists have decorated them, are only very slight modifications, founded on the development or addition of some parts which do not produce any essential change in the plan. These four great branches of the animal world are the *vertebrata, mollusca, articulata, radiata;* and the differences of these are so important that a slight explanation of them may be permitted.

"The *vertebrata* are those animals which (as man and other sucklers, birds, fishes, lizards, frogs, serpents) have a backbone and a skull with lateral appendages, within which the viscera are included, and to which the muscles are attached.

"The *mollusca,* or soft animals, have no bony skeleton; the muscles are attached to the skin, which often includes stony plates called *shells:* such molluscs are shell-fish; others are cuttle-fish, and many pulpy sea-animals.

"The *articulata* consists of *crustacea* (lobsters, etc.), insects, spiders, and annulose worms, which consist of a head and a number of successive annular portions of the body *jointed* together (to the interior of which the muscles are attached), whence the name.

"Finally, the *radiata* include the animals known under the name of zoophytes. In the preceding three branches the organs of motion and of sense were distributed symmetrically on the two sides of an axis, so that the animal has a right and a left side. In the radiata the similar members radiate from the axis in a circular manner, like the petals of a regular flower."[1]

Comparative anatomy found in Cuvier a student who appreciated its importance and revived its efficiency and honours. He saw more distinctly than any one before, that large classes of animals, when carefully examined, are but modifications of a common type; that, for example, there is, after all, a strong resemblance, when their skeletons are looked at, between a man and a bird, and also a complete analogy between the human skull and the head of a fish. It was in the pursuit after such analogies that Cuvier was led into the track where he found the basis of his new anatomical classifications.

2. *Recherches sur les Ossemens Fossiles, où l'on rétablit les caractères de plusieurs animaux dont les révolutions du globe ont détruit les espèces.* 2 edit. Paris, 1821. 7 vols. 4to, with illustrations.

For this work Cuvier had made some preparation by an essay, presented in 1810 to the Academy, on the geology of the basin of Paris, a district singularly rich in fossil remains. Montmartre and its vicinity, covered with buildings and crowded with people, would not strike many observers as a promising field for scientific exploration; but it is the peculiarity of genius to read instruction where others can find only a blank, or a record of commonplace character. Cuvier discovered in the geological construction and the fossil remains of the Paris basin, elements for the solution of the most critical scientific questions, relative not only to that locality, but to the globe at large. Long before, he had begun to treasure up facts, the collocation of which ultimately constituted his marvellous additions to human knowledge. In 1800 he finds a few teeth, in following years a few bones; and after many years' patience and skill he ascertains and demonstrates the existence and place of a number of tapir-like animals which he classed as *Lophiodon Paleotherium* and *Anoplotherium*, formerly abounding on the banks of the ponds which have left their mud and marl in the tertiary strata of the Paris basin. His anticipations seemed like prophecies, based, as they were, on a tooth or a bone; but subsequent discoveries enabled him to verify them all, so that they became parts of scientific and general knowledge. The effect of these discoveries on the scientific world was prodigious.[1]

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[1] Whewell, *History of Inductive Sciences*, vol. iii. p. 371.

"The great work of Cuvier," says Lord Brougham, "stands among those rare monuments of human genius and labour, of which each department of exertion can scarcely ever furnish more than one, eminent therefore above all the other efforts made in the same kind. In the stricter sciences, the *Principia* of Newton, and in later times its continuation and extension in La Place's *Mécanique Céleste*; in intellectual philosophy, Locke's celebrated work; in oratory, Demosthenes; in poetry, Homer, leave all competitors behind by the common consent of mankind; and Cuvier's researches in fossil osteology will probably be reckoned to prefer an equal claim to distinction among the works on comparative anatomy."[1]

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[1] See Buckland's *Bridgwater Treatise*, vol. i. pp. 83 and 140, for remarks on Cuvier.

"If," says Cuvier, "you have but the extremity of a bone well preserved, you may, by attention, consideration, and the aid of resources which analogy furnishes to skill, determine all the rest as well as if you had the entire skeleton submitted to you."[2]

The great scientific value of the work lies in its comparative anatomy, creating as it were (as we have said), the science of palæontology at a heat; but there are in it also sundry other philosophical deductions in geology, such as the following: that in the strata called primitive there are no remains of life or organized existence;—that all organized existences were not created at the same time, but at different times, probably very remote from each other, vegetables before animals, the mollusca and fishes before reptiles, and the latter before the mammalia;—that the transition limestone exhibits remains of the lowest forms of existence; and the chalk and clay conceal the remains of fishes, reptiles, and quadrupeds, beings of a former order of things, which have now disappeared;—that among fossil remains no vestige appears of man or his works;—that the fossil remains in the more recent strata are those which approach nearest to the present type of the corresponding living species; and that these strata show the former prevalence of fresh water as well as sea water. Cuvier concluded that the actual order of things on the surface of our globe did not commence at a very remote time. He agreed with Deluc and

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[1] *Dissertations on Natural Theology*, vol. ii. p. 113.

[2] *Recherches*, vol. i. p. 52. B.D., 464.

Dolomieu that the surface of the earth was subject to a vast sudden revolution five or six thousand years ago, and that this catastrophe caused the disappearance of countries formerly the abode of man and of species of animals now unknown. He also believed that the countries now inhabited had been, long before the creation of man, inhabited by animals, destroyed by previous convulsions, and that the globe has undergone successive visitations which destroyed orders of animals of which we find the remains in the various strata. In many respects Cuvier's work has been left in arrear, and some of the opinions largely rectified, by the rapid advance of scientific research: but much of it has not been superseded, and must ever remain a noble monument of the author's vast attainments and immense power.[1]

The extraordinary sagacity of Cuvier, coupled with his extensive knowledge, qualified him for the execution of this herculean task. His power of geological classification sprang out of his zoological skill, and he was a great pioneer in previously unexplored fields of research, where relations between the organic and inorganic changes of the earth were revealed to the eye of the philosopher. "His guiding ideas had been formed, his facts had been studied, by the assistance of all the sciences which could be made to bear upon them. In his geological labours he seems to see some beautiful temple, not only firm and fair in itself, but decorated with sculptures and painting, and rich in all that art and labour, memory and imagination, can contribute to its beauty."[1]

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[1] We have here largely adopted what is found in an article on Cuvier in Knight's *Biographical Dictionary*, correcting some of the statements in the light of discoveries made since the article was written.

3. *Histoire Naturelle des Poissons.* 1828.

In this work Cuvier traces the progress of ichthyology, and divides it into periods: the period of unsystematic knowledge, including works on natural history down to the sixteenth century; the period of erudition, when Bélon Rondelet and Salviani, the fathers of modern ichthyology, made their appearance; the period of accumulation in the seventeenth century, when certain scientific Dutchmen made large collections of fishes for the purpose of classification; and the period of fixation of character, heralded in by Ray and Willoughby. The first great division of the watery tribes was into *cartilaginous* and bony fishes. It was recognised by Aristotle, and retained by Cuvier. This was improved upon by Peter Artedi, a friend of Linnæus, who analysed the interior as well as the exterior parts of the watery creatures; but his basis of division has been criticised as too artificial, and a true and sound separation of a natural from an artificial method of arrangement has come to be seen as the great desideratum. Positive and distinct characters for the wider as well as narrower groups justly appeared as objects of scientific search. This was the purpose of Cuvier in his great work on ichthyology, which, unfortunately, he never completed. His method may be supposed "to be in accordance with those views of zoological philosophy which it was the business of his life to form and to apply;" and "we appear to be justified in taking Cuvier's ichthyological system as the nearest approach which has yet been made to a natural method in that department."[1] He qualified himself for his task by examining critically nearly eight thousand species of fishes.

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[1] Whewell, *Hist.*, vol. iii. p. 425.

Passing from Cuvier's philosophy to Cuvier's religion, we come upon the fact, in relation to the latter, that he was a French Protestant, warmly attached to that system of Christian faith and order which had been bequeathed to their country by the heroic Huguenots. No branch of the Church possesses a more brilliant history—a history just of that nature which would light up the genius and inspire the enthusiasm of a man like Cuvier. As a Protestant he was educated; as a Protestant he appeared at the Stuttgart examination already noticed; and as a Protestant he no doubt had his convictions deepened during his residence with the distinguished Protestant family on the coast of Normandy.

Throughout his illustrious life his religious character appears conspicuous, not in any publications on the subject, but in his indefatigable exertions for the welfare of the community with which he identified himself. This marked him out as a fitting person to be entrusted with the administration of government affairs in France, as they related to the ecclesiastical interests of the Protestants. He occupied that office with characteristic zeal and energy, and caused the creation of fifty new cures which had long been wanting. Fresh regulations for the discipline of Churches were being devised by him just before his death; and when he was removed from the world his memory was fervently eulogized by the French pastors.[2] He promoted the circulation of the Holy Scriptures, and became a vice-president of the Bible Society. He was active in the cause of religious as well as secular education; and in a discourse which he delivered at the distribution of prizes, instituted for the reward of virtuous actions, he, with all the fervour of a French orator, enforced upon his audience the primary duties of love to God and love to man.

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[1] Whewell, *Hist.*, vol. iii. p. 309.

[2] Lees' *Memoirs of Cuvier*, p. 254.

As to the bearing of Cuvier's philosophy upon the truths of religion, it has been well observed by Lord Brougham: "An act of creation, that which would now be admitted as a direct interposition of a superior intelligence and power, must have taken place. This is the sublime conclusion to which these researches (those of Cuvier) lead, conducted according to the most rigorous rules of inductive philosophy, precluding all possibility of cavil, accessible to every one who will give himself the trouble of examining the steps of the reasoning upon which they repose, and removing doubt from the mind in proportion as their apprehension removes ignorance. It is an invaluable addition to the science of natural theology, and forms a chapter as new in kind as any of the new animal species are in natural history. Such are the benefits conferred upon the great and fundamental argument of Divine intelligence and contrivance by the recent discoveries in fossil osteology."[1]

Nothing is more distinctive of Cuvier's philosophy than the doctrine of final causes. "That in the organized world we may and must adopt the belief that organization *exists for its purpose*, and that the apprehension of the purpose may guide us in seeing the meaning of the organization:" this most important principle was "brought into additional clearness and use by Cuvier."

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[1] *Dissertations on Natural Science,* vol. ii. p. 193.

The doctrine of final causes is acutely pointed out, by the writer just quoted, as favourable to scientific discovery as well as to the support of natural religion. "Those who have been discoverers in science have generally had minds the disposition of which was to believe in an intelligent Maker of the universe." To this statement the present volume bears ample testimony. And the same author goes on to say: "The scientific speculations which produced an opposite tendency were generally those which, though they might deal familiarly with known physical truths, and conjecture boldly with regard to the unknown, did not add to the number of solid generalizations."[1]

These remarks occur in connexion with Whewell's sketch of the contributions to science made by Cuvier: "I may observe, that he is allowed by all to have established on an indestructible basis many of the most important generalizations which zoology now contains; and the principal defect which his critics have pointed out has been that he did not generalize still more widely and boldly. It appears, therefore, that he cannot but be placed among the great discoverers in the studies which he pursued; and this being the case, those who look with pleasure on the tendency of the thoughts of the greatest men to an intelligence far higher than their own, must be gratified to find that he was an example of this tendency, and that the acknowledgment of a creative purpose, as well as a creative power, not only entered into his belief, but made an indispensable and prominent part of his philosophy."[1]

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[1] Whewell, *Hist.*, vol. iii. p. 388. See also Whewell's *Bridgwater Treatise on Astronomy*, pp. 342, 366.

"Beauty, richness, abundance," says Cuvier, "have been the ways of the Creator, no less than simplicity." "We conceive nature to be simply a production of the Almighty, regulated by a wisdom the laws of which can only be discovered by observation."[2]

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[1] *Hist.*, vol. iii. p. 388.

[2] Lees' *Memoirs of Cuvier*, pp. 149, 150.

JOHN DALTON.

1766–1844.

IN a Cumberland dale, at the township of Eaglefield, not far from Cockermouth, there lived in 1766 a Quaker family in humble circumstances, who shortly afterwards obtained a small copyhold estate, upon which the good man of the house brought up six children, one of them being JOHN DALTON, born in the year just mentioned. The Society of Friends in those days were much more strict in their adherence to the usages of George Fox than their descendants are at present; and it is easy to picture the drab coat and the broad-brimmed hat of the father, and the sober-coloured gown, and the neat cap, and the white kerchief of the mother, with their little ones like a flock, dressed in corresponding attire, when on first days they followed their parents to "meeting." John Dalton went to school with "Friend Fletcher," who lived in the place, and had the care of other children connected with the community. The learning communicated might not be of the highest kind, but the boy is said "to have made very considerable progress in knowledge;" and, in proof of this, we learn that at the age of twelve or thirteen, he set up school for himself, and during two winters instructed other youthful villagers, devoting his spare time to farm labour in the service of his father. Even then, he manifested a taste for mathematics, and derived assistance in the study from a neighbouring gentleman of the name of Robinson. At fifteen, the lad went to the town of Kendal, still remarkable for the number and respectability of Quaker families, and remained there for eleven years, engaged in both learning and teaching mathematics, in connexion with physical science. Here he formed the acquaintance of a blind gentleman named Gough, an amateur philosopher to whom, with the help of his library and apparatus, young Dalton was laid under great obligation for further progress. "For about eight years," he says, "during my residence at Kendal, we were intimately acquainted. Mr. Gough was as much gratified in imparting his stores of science as I was in receiving them; my use to him was chiefly in reading, writing, and making calculations and diagrams, and in participating with him in the pleasure resulting from successful investigations; but as Mr. Gough was above receiving any pecuniary recompense, the balance of advantage was greatly in my favour, and I am glad of having this opportunity of acknowledging it."

Dalton early commenced authorship by contributing to magazines, and by publishing, in 1793, *Meteorological Observations and Essays*. The same year he removed to Manchester; and in that busy hive of industry he spent the remainder of his days, now residing at the Moseley Street Institution, where he studied and taught; then giving lessons privately, at the charge of 1*s.* 6*d.* an hour; next delivering public lectures, and by different literary and scientific labours eking out a humble income until he received a royal pension, first of £150 and then of £300 per annum. Remaining a bachelor all his life, his wants were few; and to all worldly ambition he was a perfect stranger—dwelling amongst his own people, wearing a Quaker garb, using Quaker speech, cultivating Quaker habits, and stepping outside his religious circle only to associate with scientific men, in whose estimation he gradually rose to the highest pinnacle of eminence. He was welcomed in Paris with great applause, and on his return home he remarked: "If any Englishman has reason to be proud of his reception in France, I am that one." The Royal Society of London awarded him their gold medal, and at Oxford he received the honorary degree of D.C.L. It is curious to find that, when at Cambridge, Professor Whewell asked him to what he could compare his doctor's scarlet gown, and in return he pointed to the leaves of the trees. He was colour blind, and thought "the face of a laurel leaf a good match to a stick of red sealing-wax; and the back of the leaf to the lighter red of wafers." After his death, it may be observed in passing, his eyes were examined in compliance with his own instructions. He thought the peculiarity of his sight was owing to a peculiarity in the vitreous humour; but it turned out that the vitreous humour, which he thought was bluish, was really of a pale yellow, and when used as a lens presented no difference from an ordinary eye. The cause seems to have been, not in the optical apparatus, but in the condition of the brain or sensorium.

Dalton is considered to have belonged, not to the class of chemists represented by Priestley, Davy, and Leibig—enthusiastic and sanguine men, who by the originality of their genius and their brilliant powers made vast leaps in their discoveries; but to a larger class, represented by Black, Cavendish, Wollaston and others, who relied on their patience and perseverance. Perhaps a sternness of character belonged to the latter class, whilst they were more indifferent to the opinion of others than their less plodding brethren. "With regard to myself," remarks Dalton, at an anniversary meeting in Manchester, "I shall only say, seeing so many gentlemen present who are pursuing their studies, that if I have succeeded better than many who surround me in the different walks of life, it has been chiefly—nay, I may say, almost solely—from unwearied assiduity. It is not so much from any superior genius that one man possesses over another, but more from attention to study and perseverance in the objects before them, that some men rise to greater eminence than others. This it is, in my opinion, that makes one man succeed better than another." The orderliness of his habits corresponded with the mental qualities to which he ascribed his success. He regularly attended the meetings of the Society of Friends; he also regularly spent Thursday afternoon at a bowling green. For more than forty years he dined on the same day at a friend's house, and did not absent himself when the family were from home. He was punctilious to an extreme. When a student, who had missed one of his lectures, applied for a certificate, he replied, "If thou wilt come to-morrow, I will go over the lecture thou hast missed."

The scientific path along which Dalton travelled has been described in the following way:

"The blind gentleman, Mr. Gough, who exercised so beneficial an influence over his early days, added to his other tastes a love for meteorology. It was he, Dalton tells us, who first set the example of keeping a meteorological journal at Kendal, and his pupil appears to have soon acquired a relish for the same study. Doubtless he was influenced likewise by the magnificent scenery around him, of which he has left some eloquent descriptions, and was tempted by the peculiar facilities which the locality of his residence afforded for every kind of meteorological inquiry."[1] He made daily memoranda relative to the weather, and not content with the use of the rain-gauge, penetrated into the depths of meteorological science, inquiring into theories of the wind, the causes of alterations in the state of the atmosphere, and the phenomena of spontaneous evaporation. The books he wanted to help him at Kendal he found at Manchester, where, assisted and stimulated by the history of philosophy, he prosecuted his original researches with increased ardour.

In 1790, he wrote a paper describing "experiments and observations to determine whether the quantity of rain and dew is equal to the quantity of water carried off by the rivers, and raised by evaporation, with an inquiry into the origin of springs"—the whole of which demonstrated what we read in the Bible: "All the rivers run into the sea; yet the sea is not full: unto the place from whence the rivers come, thither they return again." Experiments and observations on the power of fluids to convey heat; others on heat and cold produced by the condensation and rarefaction of air; and again, additional ones on steam and vapour, followed in succession. He ascertained that when two elastic fluids are mixed together, there is no mutual repulsion of their particles; the particles of A do not repel those of B, as they do one another; and that the pressure, or whole weight, upon any one particle arises from those of its own kind. This led to important consequences. In 1803, he wrote on the absorption of gases by water and other liquids, and compared his gas dissolved in water to a pile of shot: a particle of gas, he says, pressing on the surface of water, is analogous to a single shot pressing upon the summit of a square pile of them.[1] To this he added an inquiry into the relative weights of the ultimate particles of bodies, which was a subject, as far as he knew, entirely novel. He weighed gases, and published a table of the *atomic weights*, as he called them, of hydrogen, oxygen, carburetted hydrogen from stagnant water, and olefiant gas. He was thus conducted to the discovery of the laws of combining proportions.

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[1] *British Quarterly Review*, vol. i. p. 177. To the article on Dalton we are much indebted.

"Dalton's views of chemical combination, including both the facts and the hypothesis which expressed and explained them, are generally known as his atomic theory. To Dalton himself the evidence in support of the existence of ultimate indivisible particles appears to have seemed so conclusive, that he considered the doctrine of atoms in the light of an induction from the data furnished by observation and experiment; and this without reference to any other than purely physical questions. We cannot indeed sufficiently reiterate that he was an atomist before he was a chemist.

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[1] *British Quarterly Review*, vol. i. p. 181.

In his lips, therefore, the name 'atomic theory' was consistent and had a clear meaning. It was John Dalton's atomic theory of chemical combining proportions: his theory of atoms, connected with his discoveries in chemistry, so as at once to account for and expound them. To those, however, who cannot by any process of generalization establish to their own satisfaction, or to that of others, the actual existence of atoms (and it includes almost every one who thinks on the subject at all), and for whom the doctrine of atoms is only a questionable, and we may say an indifferent hypothesis, Dalton's view is an atomic hypothesis of combining proportion. It matters comparatively little, however, whether we say atomic theory or atomic hypothesis, provided we keep perfectly distinct what is matter of assumption concerning atoms from what is matter of fact concerning laws of combining proportion."[1]

The word "atom" may be popularly used in the same way as the word "element." It may be employed to indicate the minutest particle to which analysis can reduce a substance in nature, without intending thereby to affirm that such a particle can be analysed no further. What actually constitutes the primordial essence, or basis of matter, has been an inquiry agitated in all ages; and though different theories may be broached on the subject, absolute satisfaction is far from being reached. At all events, that point at which analysis is compelled for the present to stop may be, without danger of misapprehension, denominated an atom, leaving it still an open question what an atom is. It may here be added, that for the word "atom" Davy substituted the word "proportion," and Wollaston the word "equivalent," which is now generally used; and Dr. Whewell remarks, "The general laws of chemical combination announced by Mr. Dalton are truths of the highest importance in the science, and are now nowhere contested; but the view of matter as constituted of *atoms*, which he has employed in conveying those laws, and in expressing his opinion of their cause, is neither so important nor so certain."[1]

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[1] *British Quarterly Review*, vol. i. p. 183.

"The announcement of the atomic theory to the chemists of Europe was like a lighted torch passed round among lamps trimmed and filled with oil, and ready to be kindled. Some heard with incredulity, like Davy, others with gladness, like Thomson, none probably, without astonishment, that the humble teacher of mathematics had extracted more meaning out of his imperfect and even inaccurate analysis than they—even Berzelius and Wollaston—out of their scrupulously exact ones. It was so, however. In Spain, France, Germany, Sweden, and elsewhere, many were seeking to discover the laws regulating chemical combination, every one of them probably acquainted with a wider range of chemical phenomena and a better analyist than Dalton; but he beat them all. So true is it, what Thomas Carlyle says, 'the eye sees what it brings the power to see.'"

"At the time when he made his discovery, there was not a single chemical analysis which could properly be considered as correct; there was not a single gas whose specific gravity was known with any approach to accuracy; and Dalton displayed infinite sagacity in coming so near the truth as he did. Since the introduction of the atomic theory, the knowledge of chemical combination has been simplified to an amazing extent, and the processes of analysis, which constitute the essence of chemistry, have assumed a degree of accuracy almost approaching to mathematical precision. Manufactures have been benefited as well as science; the quantity of each constituent of any article can be regulated with perfect accuracy, so that there is no waste; and the result of the combination can be reckoned upon with unfailing certainty."[1]

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[1] *Hist. of Inductive Sciences*, vol. iii. p. 127.

The chief laws of chemical combination, as stated by Dalton, are: that the same compound consists invariably of the same constituents: that the elements of every compound always unite in the same proportion by weight: that when any element is in more proportions than one, those proportions are multiples—1, 2, 3, 4; 6, 12, 18, 24; 8, 16, 24, 32, and so on: that if two substances combine in a certain proportion with a third, they continue in exactly the same proportion with each other: and that the combining proportion of a compound is the sum of its constituents.

Dalton lived to be seventy-eight. Seven years before his death he had a paralytic seizure, and a second followed in 1844. In the July of that year, an address was presented to him acknowledging his services, when, not being able to give an articulate reply, he handed a written paper to this effect: "I feel gratified by this testimony of kind regard offered to me by my old associates of the Literary and Philosophical Society of Manchester. At my age and under my infirmities, I can only thank you for this manifestation of sentiments, which I heartily reciprocate." A little more than a week afterwards, he quietly expired.

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[1] C. Knight's *Biog. Dict.*, art. "Dalton."

It is strange to find, that though a Quaker, he was laid in state in the Manchester Town Hall, and had a public funeral, much to the displeasure of the Friends, with whose tastes and habits it was utterly out of keeping: and could it have been proposed to the philosopher himself, it would have met with his firm, if not severe disapprobation.

No particulars respecting his religious history, except of the most general kind, have been preserved, that we are aware of; nor did he, we believe, publish any theological work whatever. Indeed, the body to which he belonged are on principle averse to the free expression of spiritual experience, and regard communion between the Christian and the Saviour as amongst the sacred secrets of the soul; nor, with few exceptions, have they been wont to publish works on theology in general. But Dalton's steady attachment to Quaker principles from youth to old age, indicate sufficiently the absence of all sympathy in his mind with that scepticism respecting revelation which has in some cases haunted scientific students. We think of him "at meeting," as devoutly lifting up his heart to God in adoration and praise, as he silently mused on the power, and wisdom, and goodness of Him who "weighed the mountains in scales and the hills in the balance;" who "giveth rain in due season;" and who maketh "the dew to lie all night upon the branch." And, as it has ever been the special vocation of the society to testify to the immediate work of the Holy Spirit on the mind of man, he would recognise in the rain and the dew, whose laws he studied so wisely and so well, symbols of gracious operations still more precious than any which can be discovered in the depth of nature's secrets.

MICHAEL FARADAY.

1791–1867.

"SIR HUMPHREY DAVY has the honour to inform the Managers, that he has found a person who is desirous to occupy the situation in the Institution lately filled by William Payne. His name is Michael Faraday. He is a youth of twenty-two years of age. As far as Sir H. Davy has been able to observe, or ascertain, he appears well fitted for the situation; his habits seem good, his disposition active and cheerful, and his manner intelligent. He is willing to engage himself on the same terms as those given to Mr. Payne at the time of quitting the Institution.—Resolved, that Michael Faraday be engaged to fill the situation lately occupied by Mr. Payne on the same terms."[1] So runs the record of Faraday's first association with Davy, and of Faraday's first connexion with the Royal Institution;—incidents closely related, and destined to lead to wonderful results in the case of a poor and humble young man, and through him to enlarge the boundaries of science and to benefit the world to the end of time.

Faraday was a London lad, born in 1791; for some time he lived with his parents in the upper rooms of a coach-house in Wells Mews, Charles Street, Manchester

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[1] Dated March 1st, 1813.

Square; then he removed to Blandford Street, where he was errand-boy to a bookseller and newsvendor. After he rose to high renown, he would point to the little urchins plying their trade round the door-steps of an omnibus, saying, "I always feel a tenderness for these boys, because I once carried newspapers myself." The passion for science soon appeared. Marcet's *Conversations on Chemistry* and the electrical treatises in the *Encyclopedia Britannica* wonderfully excited the curiosity and fired the aspirations of the young tyro, as he pondered the contents of the volumes; and with such pence as he could save he constructed an electrical machine, with a glass phial for want of a real cylinder. He learned to sketch, attended lectures, and availed himself of every book and every help he could lay hold of, to make his way through paths of knowledge at first beset with enormous difficulties. But he overcame them all.

The entry just quoted shows the turning-point in his history. First he became acquainted with Sir Humphrey Davy, and Sir Humphrey at that time was a sort of scientific prince, whose favour and patronage were of great value; whilst his knowledge and example could not but largely instruct and powerfully animate a youth of genius like Faraday. Faraday worked hard at the Royal Institution, engaged in such chemical preparations and experiments as he was able to undertake, and helped his master in every way he could. Sir Humphrey took the youth with him in a long tour on the Continent, which proved eminently beneficial in sharpening the youth's curiosity, enlarging his mind, bringing him within the circle of illustrious scientific foreigners, opening up to him methods of inquiry pursued abroad, and enabling him to acquire a knowledge of other languages than his own—an acquisition of great worth to him in later days, when he attracted the attention of all Europe. The letters he wrote home during his travels are full of interest. He seems to have had an eye for almost everything worth looking at; but men and manners, perhaps more than Art, secured his notice; and nature in its scientific aspects stood high in the young traveller's regards. It is curious to find him one Sunday at Geneva, in 1814, examining a glow-worm. "This evening many glow-worms appeared; and of four which I had put in a tumbler with green leaves, two shone very brightly. I separated the luminous part of one in full vigour from the body. It soon faded, and in about ten minutes ceased to emit light; but on pressing it with a knife, so as to force the matter out of the skin, it again became luminous, and continued to shine for two hours brightly. One I found on the floor, crushed unawares by the foot. I separated the luminous part of this insect, and left it on paper. It shone with undiminished lustre the whole evening, and appeared not at all to have suffered in its power of emitting light by the mixture and confusion of its parts, so that it appears to depend more upon the *chemical* nature of the substance than upon the vital powers of the animal; but at the same time it appears from the variations in splendour accompanied by motions in the living animal, that it may be much influenced or modified by, or in some manner submitted to, the power of the worm." "The matter, which appears to fill the hinder part of the body in the shining season, is yellowish-white, soft, and glutinous. It is insoluble apparently in water or in alcohol. It does not immediately lose its power of shining in them, but it is sooner extinct in alcohol or in water."[1] Hundreds of naturalists would examine glow-worms, and discover in them much that is wonderful; but here we see a naturalist and a chemist combined, and the chemist is more conspicuous than the naturalist, though young Faraday has more to say about the form and structure of the worm than we have space to quote.

Sir Humphrey, by taking his assistant abroad, and by the instructions he imparted to him at home,—by the employment he gave him at the Royal Institution, and by the general influence of his character and example,—was to him a great benefactor; and Faraday was not slow to acknowledge the obligation. He spoke of his exalted friend in terms of strong admiration and deep gratitude; but it is very far from pleasant to find that Davy became jealous of the young man as he rose in knowledge and fame, and was unfriendly to his election as Fellow of the Royal Society: time and circumstances, however, softened and, one would hope, at last extinguished this feeling. Moreover, it should be noticed that there were defects in Sir Humphrey which Faraday observed, and the observation of which, by a stroke of wisdom worth being imitated by those addicted to hero-worship, he turned to his own advantage. "With all his genius, Davy was hurt by his own great success. He had very little self-control and but little method and order. He gave Faraday every opportunity of studying the example which was set before him during the journey abroad, and during their constant intercourse in the laboratory of the Royal Institution; and Faraday has been known to say, that the greatest of all his advantages was, that he had *a model to teach him what he should avoid.*"[1]

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[1] *Life and Letters of Faraday*, vol. i. p. 144.

Faraday's connexion with the Royal Institution, which commenced in the manner we have seen, continued to the end of life; and when he became a lecturer, he rose to a height of popularity rarely equalled and never surpassed. Princes, nobles, and scientific men, rank and fashion, people of all classes, crowded the amphitheatre to listen to what he had to say, and to witness what he had to do. There was perfect harmony between his lessons and his experiments. Both the one and the other were clear, distinct, and pertinent. Neither confused in thought nor in expression, he conveyed a precise idea of his meaning; neither irrelevant nor blundering in his illustrations, he demonstrated what he said, and nailed down his arguments with resistless force. He had a happy method of teaching scientifically the humblest subjects, and could gracefully, without the touch of a pedant, communicate even profound information when discoursing on a tea-kettle. Children he could interest to an extraordinary degree, and his juvenile lectures were amongst his happiest efforts.

Dr. Tyndall has done justice to Faraday's qualities as a lecturer on science. The following extract will be appreciated by the scientific reader. It relates to terrestrial magneto-electric induction, and to the force and direction of magneto-electric induction.

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[1] *Life and Letters of Faraday*, vol. i. p. 210.

"He now passes from his little brass globe to the globe of the earth. He plays like a magician with the earth's magnetism. He sees the invisible lines along which its magnetic action is exerted, and sweeping his wand across these lines, he evokes this new power. Placing a simple loop of wire round a magnetic needle, he bends its upper portion to the west; the north pole of the needle immediately swerves to the east: he bends his loop to the east, and the north pole moves to the west. Suspending a common bar magnet in a vertical position, he causes it to spin round its own axis. Its pole being connected with one end of a galvanometer wire, and its equator with the other end, electricity rushes round the galvanometer from the rotating magnet. He remarks upon the 'singular independence' of the magnetism and the body of the magnet which carries it. The steel behaves as if it were isolated from its own magnetism.

"And then his thoughts suddenly widen, and he asks himself whether the rotating earth does not generate induced currents as it turns round its axis from west to east. In his experiment with the twirling magnet the galvanometer wire remained at rest; one portion of the circuit was in motion relatively to another portion. But in the case of the twirling planet the galvanometer wire would necessarily be carried along with the earth; there would be no relative motion. What must be the consequence? Take the case of a telegraph wire with its two terminal plates dipped into the earth, and suppose the wire to lie in the magnetic meridian. The ground underneath the wire is influenced, like the wire itself, by the earth's rotation; if a current from south to north be generated in the wire, a similar current from south to north would be generated in the earth under the wire; these currents would run against the same terminal plate, and thus neutralise each other."[1]

Another extract of a very different kind, and much more intelligible to the generality of readers, gives us a glimpse of the Lecturer's private habits. It is supplied by his niece, who lived with Mr. and Mrs. Faraday at the Institution from 1830 to 1840.

"We often found him hard at work on experiments connected with his researches, his apron full of holes. If very busy he would merely give a nod, and aunt would sit down quietly with me in the distance, till presently he would make a note on his slate and turn round to us for a talk; or perhaps he would agree to come upstairs to finish the evening with a game at bagatelle, stipulating for half an hour's quiet work first to finish his experiment. He was fond of all ingenious games, and he always excelled in them. For a time he took up the Chinese puzzle, and, after making all the figures in the book, he set to work and produced a new set of figures of his own, neatly drawn, and perfectly accurate in their proportions, which those in the book were not. Another time, when he had been unwell, he amused himself with papyroplastics, and with his dexterous fingers made a chest of drawers and pigeon-house, etc. When dull and dispirited, as sometimes he was to an extreme degree, my aunt used to carry him off to Brighton, or somewhere, for a few days, and they generally came back refreshed and invigorated. Once they had very wet weather in some out-of-the-way place, and there was a want of amusement, so he ruled a sheet of paper and made a neat draught-board, on which they played games with pink and white lozenges for draughts. But my aunt used to give up almost all the games in turn, as he soon became the better player, and, as she said, there was no fun in being always beaten. At bagatelle, however, she kept the supremacy, and it was long a favourite, on account of its being a cheerful game requiring a little moving about. Often of an evening they would go to the Zoological Gardens and find interest in all the animals, especially the new arrivals, though he was always much diverted by the tricks of the monkeys. We have seen him laugh till the tears ran down his cheeks as he watched them. He never missed seeing the wonderful sights of the acrobats and tumblers, giants and dwarfs; even Punch and Judy was an unfailing source of delight, whether he looked at the performance or at the admiring gaping crowd."[1]

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[1] *Life and Letters*, vol. ii. pp. 13, 14.

Large and most important additions were made to the science of chemistry by the two philosophers brought together in the singular way described, and the circumstance has led an eminent historian of the inductive sciences to denominate the period of their discoveries as *the Epoch of Davy and Faraday*.[2] The discoveries relate to the electro-chemical theory, as it is called, and involve a great deal which it is impossible here to describe. The difference between Faraday and Davy is clearly pointed out. Davy, though apparently exact in expression, sometimes spoke of the same thing in such different ways as were irreconcilable; and there was such a vagueness too in what he advanced as a precise exposition of his subject, that various theories might be started, all in accordance with the philosopher's phraseology. Faraday says, that though in Davy's celebrated Memoir of 1806 the points established are of the utmost value, "the mode of action by which the effects take place is stated very generally; so generally, indeed, that probably a dozen precise schemes of electro-chemical action might be drawn up, differing essentially from each other, yet all agreeing with the statement there given; and at a period a little later, being reproached by Davy's brother with injustice in this expression, he substantiated his assertion by an enumeration of twelve such schemes which had been published."[1]

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[1] *Life and Letters*, vol. ii. p. 113.

[2] Whewell's *History*, vol. ii. book xiv. chap. 8.

Faraday engaged in a series of *Experimental Researches,* which appear in the *Philosophical Transactions,* numbered successively from 1 to 2453, in the month of September, 1846. A vigorous method of investigation and reasoning runs through the whole body of them, though the connexion between one and another is at first sight by no means obvious. The earliest relate to voltaic induction, and the evolution of electricity from magnetism. In the third series, his "object was, as a preparatory step towards further investigation, to show the identity of voltaic and animal electricity with that of the electrical machine; and as machine electricity differs from the other kinds, in being successively in a state of tension and explosion, instead of a continued current, Mr. Faraday succeeded in identify-ing it with them by causing the electrical discharge to pass through a bad conductor into a discharging train of vast extent, of nothing less indeed than the whole fabric of the metallic gas-pipes and water-pipes of London." As the result of his experiments he stated, "that the influence which is present in the electric current may be described as an axis of power having at each point contrary forces, exactly equal in amount in contrary directions." The identity of electrical and chemical forces, hazarded by Davy as a conjecture, became the continuous and favourite study of his successor; but a number of recondite facts and principles in relation to it were evolved. Faraday confirmed and illustrated what Davy guessed. What had been vaguely indicated by the latter became precisely expressed by the former. "The confirmation of Davy's discoveries by Faraday, is of the nature of Newton's confirmation of the views of Borelli and Hooke respecting gravity, or like Young's confirmation of the undulatory theory of Huyghens." Faraday conceived that he had transferred the electro-chemical theory from the domain of what he calls doubtful knowledge to that of inductive certainty. And, in connexion with these laborious and subtle researches, he constructed what he denominated *the volta electrometer*, an instrument for measuring the force of electricity, which led to further astounding results. By it the inventor showed that one grain of water requires "for its decomposition as much electricity as would make a powerful flash of lightning"—that this quantity is "not less than 800,000 charges of the Leyden battery, and this is, by his theory of the identity of the combining with the decomposing force, the quantity of electricity which is naturally associated with the elements of the grain of water endowing them with their mutual affinity."[1]

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[1] *Life and Letters,* vol. iii. p. 140.

In 1845, Faraday sent to Sir J. F. W. Herschel a sealed packet, telling him that he might open it if he liked. It enclosed the following note, to which Herschel sent a reply well worth quoting.

"I have reason from experiment to think that a ray is not indifferent as to its line of path, but has different properties in its two directions, and that by opposing rays edgeways, new results will be obtained. I have ordered apparatus already for the experimental investigation of this point, and only want *time*. I have already made a certain progress in the endeavour to obtain electric currents or magnetic force from light, by the use of circular polarisation natural and constrained, and also on other principles which I need not advert to here.

"M. FARADAY."

SIR JOHN HERSCHEL TO FARADAY.

"My dear Sir,—You did not surely think me so incurious, or rather so deficient in interest, respecting the astonishing series of discoveries into which you are now entered fairly, that, having your express permission to open the paper you sent me sealed, I should not avail myself of it. Accordingly, I have done so, but I thought it best to reinclose it to you, rather than consign it to the flames, which I would not do to a bit of your handwriting. Should the first of your views expressed in it be really verified, a new field of speculation on the nature of light will be opened, as I do not understand what the undulatory or indeed any theory can have to say to a fact of that nature.

"Go on and prosper—'from strength to strength,' like a victor marching with assured steps to further conquests; and be assured that no voice will join more heartily in the pæans that already begin to rise, and will speedily swell into a shout of triumph, astounding even to yourself, than that of

"Yours most truly,
"J. F. W. HERSCHEL."[2]

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[1] Whewell, vol. iii. p. 149.

[2] *Life and Letters*, vol. ii. p. 202.

Faraday was addicted in almost equal degrees to patient experiment and brilliant theorizing; but he never mistook a mere theory for a demonstrated doctrine. No man, with a vigorous and vivid imagination, perhaps ever knew better, if so well, how to keep it in check and to regard it as a servant rather than a master. He could speculate with amazing originality, but he treated his speculations as speculations, rating them at just what they were worth and no more.

"It is the operation of a mind filled with thoughts of this profound, strange, and subtle character that we have to take into account in dealing with Faraday's later researches. A similar cast of thought pervades a letter addressed by Faraday to Mr. Richard Phillips, and published in the *Philosophical Magazine* for May, 1846. It is entitled "Thoughts on Ray-Vibrations," and it contains one of the most singular speculations that ever emanated from a scientific mind. It must be remembered here, that though Faraday lived amid such speculations, he did not rate them highly, and that he was prepared at any moment to change them or let them go. They spurred him on, but they did not hamper him. His theoretic notions were fluent; and when minds less plastic than his own attempted to render those fluxional images rigid, he rebelled. He warns Phillips, moreover, that from first to last 'he merely threw out as matter for speculation the vague impressions of his mind; for he gave nothing as the result of sufficient consideration, or as the settled conviction, or even probable conclusion at which he had arrived.'"[1]

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[1] *Life and Letters*, vol. ii. p. 278.

Of the common habit of misrepresenting the opinion of great teachers, a remarkable instance occurs in the case of Faraday. This appears from bringing together two letters, one addressed to him by Mr. Stroud, and another which he wrote to that gentleman in reply. An extract from the former is subjoined, with Faraday's answer.

MR. STROUD TO FARADAY.

"When combating the Old Testament narrative of the creation of man, he (Mr. Wyld) adverted to certain chemical experiments which he has alleged were made by you some years since, before audiences, both at Oxford and Cambridge, and also in London, when you demonstrated that life was but electricity, by producing through its agency animalcules, maggots, etc., accompanying those experiments by remarks addressed to your audiences, as: 'Gentlemen, there is life, and, for aught I can tell, man was so created.' Mr. Wyld has always held it (and has related the circumstance to show) that you inferred from your experiments that man could be created or generated, and in all probability was created, in the same *modus operandi* as by your experiments. Mr. W., in relating the above, has always related that so unpalatable were your views and contrary to what was received as orthodox, that the authorities under whose auspices the lectures were given (at which you experimented), had them discontinued."

FARADAY TO MR. STROUD.

"Your letter has surprised me a good deal, for I did not know before, that my name had been used as you describe, and cannot now imagine how it has been employed upon that side of the argument where your letter places it. I send herewith a part of your letter (which, however, I will thank you to return to me again). All that part which is between my initials on pp. 5 and 6 [the above-cited extract] is utterly untrue. I never made animalcules or maggots by the agency of electricity, and when others said they had done anything of the kind, opposed their views, and all the conclusions derived from them. I never lectured on science at Cambridge at all; no lectures of mine have been discontinued; and if I have given offence (which I can only imagine in the case of one person), [1] it has been because I was supposed to pay too much respect to the Bible, which I believe to be the Word of God.

"Some years ago I delivered a lecture on education, which has been reprinted at the end of a volume of Juvenile Lectures on the forces of matter, just published by Griffin, I believe. Near the beginning of that lecture you will find a public answer to the inquiries which you make at the close of your note.

"Your letter states that the object of the meetings on Paddington Green is the elucidation of truth. As far as your letter goes, they appear to have been effectual mainly in the generation and propagation of *error*.

"You are at perfect liberty to use this letter in connexion with the subject in any way you may think fit." [2]

This brings us at once to the religious side of Michael Faraday's character. His parents belonged to the *Sandemanian* denomination, so called from Robert Sandeman, who in connexion with certain ecclesiastical peculiarities of an ultra-independent nature, held that Christian faith is of an intellectual rather than a moral character, and has its origin in the understanding, not in the affections. In the tenets of that sect Michael was brought up, and he remained firmly attached to them until the day of his death. Not only was he member of a Sandemanian Church in London, but he became a preaching elder. In 1840 he was elected to the office, and continued regularly afterwards to deliver sermons to the little flock on alternate Sundays. He did not carry into the pulpit the eloquence of the lecture-room. The overflowing energy and clearness characteristic of the latter were "replaced by an earnestness of manner, best summed up in the word devoutness. His object seemed to be to make the most use of the words of Scripture, and to make as little of his own as he could."[1]

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[1] This was in the Lecture on Mental Education in 1854, by the sentence, "Let no man suppose for a moment that the self-education I am about to commend in respect to the things of this life extends to any considerations of the hope set before us, as if man by reasoning could find out God."

[2] *Life and Letters of Faraday*, vol. ii. pp. 441, 442.

Sandemanian views may be termed *Evangelical,* with a tincture derived from the characteristic tenet just specified. Faraday therefore appears as an advocate of the Gospel of Christ, according to the views of those who give prominence to the doctrines of the Atonement, and Justification by faith. But what appears singular in connexion with his Sandemanian peculiarity of belief, he does not seem to have looked *intellectually,* as one might say, to the truths of the New Testament, so as to form them into anything like a system. The spirit of a little child, receiving the truth in the love of it, seems rather to have been the mental attitude of this philosopher. We can discover in the few passages on the subject contained in his *Life* no indication of the way in which he grasped it with his understanding, but we see clearly enough the place it had in his heart. From this noticeable fact in his religious history there proceeded another—the complete severance in his mind between what pertains to science and what pertains to religion. So far from attempting to reconcile the inductions of the one with the authoritative teachings of the other, so far from endeavouring to ascertain and define their mutual relations whatever they may be, he left the matter just as he found it. Science and religion occupied two distinct spheres in his mind; and philosopher as he was, curious as he was respecting chemistry and electricity, and their connexion with each other, he never seems to have troubled himself as to how the two subjects to him of highest interest, science and religion, were to be placed in juxtaposition, or on what grounds he considered it his duty to let them stand totally apart; at all events, he regarded an express Revelation from God as an object to be studied after a different manner from the works of His hands, whose laws lie hidden and have to be brought to light by the exercise of the human intellect. We are here simply stating a fact with regard to Faraday, not any opinion of our own as to differences between physical science and theology.

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[1] *Life and Letters,* vol. ii. p. 100.

In a letter to a lady, who wished to become his disciple, he lays down the postulate of separation without giving any reason. "You speak of religion, and here you will be sadly disappointed in me. You will perhaps remember that I guessed, and not very far aside, your tendency in this respect. Your confidence in me claims in return mine to you, which indeed I have no hesitation to give on fitting occasions, but these I think are very few, for in my mind religious conversation is generally in vain. There is no philosophy in my religion. I am of a very small and despised sect of Christians, known, if known at all, as Sandemanians, and our hope is founded on the faith that is in Christ. But though the natural works of God can never by any possibility come in contradiction with the higher things that belong to our future existence, and must with everything concerning Him ever glorify Him, still I do not think it at all necessary to tie the study of the natural sciences and religion together, and in my intercourse with my fellow-creatures, that which is religious, and that which is philosophical, have ever been two distinct things."[1] Whatever may be thought of this view, and various opinions may be formed of it both amongst philosophers and Christians, this is plain, in Faraday's case, that with all his large knowledge of nature and all his scientific acuteness in its investigation, he saw nothing anywhere which shook his faith in the Scriptures as containing a Divine Revelation. He could have no sympathy whatever with those who contend that if modern science be true, much of what is commonly regarded as Christianity, and of what was included in *his* creed, must be false.

It was only in accordance with his Sandemanian notion of faith, that he should look upon *Religious Revivals* with suspicion, to use no stronger term. He wrote an opinion on the subject, in compliance with the wishes of some one, and in that opinion occurs a passage which—whilst it shows that he was not so acute and clear in his theology as he was in his philosophy—shows also that he had an eye to see various influences which affect men's minds with regard to what is false, and that his idea of the source of all genuine illumination as to the things of God is to be found in the Spirit of God—that Spirit speaking in the Word, that Spirit entering into and dwelling within the heart. "That man in his natural state is greatly influenced by his fellow-creatures and the forms of emotion which are amongst them, is doubtless true, even when it concerns what he considers his eternal welfare. How else would the wonderfully varied and superstitious forms of belief have obtained in the world? What carries the Mormons into the desert, surrounded by trouble and the enmity of those around them? What sustains a spiritual dominion like the Papacy, aided by the nations around it, to proclaim the name of Christ whilst it contradicts His Word—refuses it (the record of the Spirit) to the people—and crushes out, with all intolerance, the simple obedience of the truth? Man's natural mind is a very unstable thing, and most credulous, and the imagination often rules it when reason is thought to be there. Mesmerism has great power over it; so has poetry; so has music; so has the united voice of the multitude; so have many other things; but these things are, so to say, indifferent as respects the *character* of the object: they may be used to sustain and are just as powerful in favour of a bad cause as a good one. Among the contradictory and gross systems of religion, or the numerous and opposed systems of political government, any one of them may be sustained by the use of such agencies as these. The Christian religion is a revelation. The natural man cannot know it. He, not knowing it, is liable in respect of religion to all the influences before mentioned, finds in them snares and delusions, and either becomes an infidel or is subject to every wind of doctrine. The Christian religion is a revelation, and that revelation is in the Word of God. According to the promise of

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[1] *Life and Letters,* vol. ii. p. 195.

God, that Word is sent into all the world. Every call and every promise is made freely to every man to whom that Word cometh. No revival and no temporal teaching comes between it and him. He who is taught of the Holy Spirit needs no crowd and no revival to teach him; if he stand alone he is fully taught, for the Comforter (the Spirit) taketh of the things of Christ and showeth them to His people. And if in the mercy of God it *should* please Him that one seeing the commotion about him should be led to examine his ways, it will only be in the Word of the testimony, the Word of God, that he will find the revelation of the new and living way by which he may rejoice in hope of entering the kingdom of Christ."[1]

Faraday's character is well summed up by his biographer. "As a man, the beauty and nobleness of his character was formed by very many great qualities. Among these the first and greatest was his truthfulness. His noble nature showed itself in his search for truth. He loved truth beyond all other things; and no one ever did or will search for it with more energy than he did.

"His second great quality was his kindness (agapê). It was born in him, and by his careful culture it grew up to be the rule of his life; kindness to every one, always—in thought, in word, and in deed.

"His third great quality was his energy. This was no strong effort for a short time, but a lifelong lasting strife to seek and say that which he thought was true, and to do that which he thought was kind.

"Some will consider that his strong religious feeling was the prime cause of these great qualities; and there is no doubt that one of his natural qualities was greatly strengthened by his religion. It produced what may well be called his marvellous humility.

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[1] *Life and Letters*, vol. ii. p. 431.

"That one who had been a newspaper boy should receive, unsought, almost every honour which every republic of science throughout the world could give; that he should be for many years consulted constantly by the different departments of the Government, and other authorities, on questions regarding the good of others; that he should be sought after by the princes of his own and of other countries; and that he should be the admiration of every scientific or unscientific person who knew anything of him, was enough to have made him proud; but his religion was a living root of fresh humility, and from first to last it may be seen growing with his frame and reaching its height with his glory, and making him to the end of his life certainly the humblest, whilst he was also the most energetic, the truest, and the kindest of experimental philosophers.

"To complete this picture, one word more must be said of his religion. His standard of duty was supernatural. It was not founded upon any intuitive ideas of right and wrong; nor was it fashioned upon any outward expediencies of time and place; but it was formed entirely on what he held to be the revelation of the will of God in the written Word, and throughout all his life his faith led him to act up to the very letter of it."[1]

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[1] *Life and Letters*, vol. ii. p. 485.

In the Highgate Cemetery stands a plain gravestone bearing the inscription—

MICHAEL FARADAY.
Born 22nd September,
1791.
Died 25th August,
1867.

DAVID BREWSTER.

1781–1869.

LITERATURE and science are at times antagonistic to each other. Literature may be jealous of science, and science may be jealous of literature. When science is in the ascendant, and attracts more attention in the intellectual world than literature, literature is apt to depreciate her sister as cold and hard; and when their relative positions are just the opposite, then science is tempted to treat her rival as visionary and romantic. The former deals with simple facts, and applies to them rules of severe reasoning; the latter seeks delight in realms of imagination, and loves to describe what is picturesque in history, as well as to penetrate into political and moral laws which govern mankind. Collisions no less than divergences may be expected occasionally in such different careers. At times, however, they stand quite apart, dwelling in totally distinct realms. The literary man is perhaps ignorant of science, never meddles with mathematics pure or mixed, and is a perfect stranger to the telescope and the laboratory; or the man of science cares only for observations and experiments, never cultivates the study of polite letters, and in describing his own discoveries, and those of others, is utterly negligent as to the style in which they are expressed.

The opposition and the severance are equally unnatural. Relations between the sisters, for sisters they are, should be mutually kind and helpful. It is but reasonable that men who study what may be called "the fine arts" in the domain of literature, should watch with interest fellow-labourers in neighbouring fields of natural research and discovery; and that these fellow-labourers should look over the hedge with mutual goodwill, and, in detailing what they have achieved themselves, be not inattentive to forms of language such as their neighbours cultivate.

Numerous examples of such friendly relations, and of the union of literature and science in the same person, occur in the present day—perhaps beyond what can be found at earlier periods. An instance of the kind in the last generation now claims attention.

DAVID BREWSTER was born at Jedburgh, in Scotland, in December, 1781, and studied at Edinburgh, where he numbered amongst his friends, Dugald Stewart and John Playfair. Graces of thought and style would be learnt from Stewart, scientific inquisitiveness would be learnt from Playfair. Brewster was intended for the Church, but he felt himself more fit for the laboratory than the pulpit, and without losing interest in religion, devoted his life to natural science. He married the daughter of Macpherson, editor or author of "Ossian," and here we have another symbol, that of union between a votary of philosophy and a daughter of song; and if a rather fanciful allusion may be forgiven, the bridegroom was destined in himself to embody the spirit of two of the muses, seeing that he became both historian and astronomer.

Brewster's love of literature early manifested itself, and stands out prominently in his biography until the close of life. As early as 1808, he undertook the editorship of the *Edinburgh Encyclopædia*, and continued to occupy that important post until the completion of the enterprise in 1830. He contributed to the work biographies of D'Alembert, Bailly, Bernouilli, Bradley, Tycho Brahè, Buffon, Condorcet, Copernicus, Euler, Galileo, and Halley. Combined with a keen appreciation of scientific pursuits and discoveries, he had a clear, impartial, and conscientious judgment, and was careful to weigh in the balance of criticism the merits of these illustrious men. In more advanced life Brewster wrote his *Martyrs of Science*, in which little volume, dated 1841, he gracefully, though slightly, again portrayed the lives of Galileo and Tycho Brahè, and added to them one more, a sketch of the astronomer Kepler. His *Memoirs of Sir Isaac Newton* appeared in 1855, in two volumes, and all that can now be known of the illustrious philosopher is told with clearness and beauty: "his discoveries are discussed, his inventions described, the character of the most eminent of his companions drawn, and we follow him to the observatory, the study, the Royal Society, and the private chamber."[1] The biography was severely criticised in several quarters; there are, however, few who have perused its pages but will agree in pronouncing it an interesting and instructive specimen of modern biography. Eloquent reflections are blended with lucid narratives of facts and explicit statements of philosophical theories. Brewster delighted to traverse fields of speculation, and following out the astronomical bent of his mind, he published, in 1854, *More Worlds than One: the Creed of the Philosopher, and the Hope of the Christian.* Here, as the title imports, he combined science and religion, an union he was ever anxious to maintain; the popularity of the books repaid his labour, and extended his fame beyond the circle of scientific readers. We well remember the interest it excited amongst religious people, and the controversy it produced; his speculations having indeed been called forth by a book entitled *The Plurality of Worlds,* (attributed to Dr. Whewell and never denied by him, in which the popular theory was met not so much by a decided negative, as by an attempt to show that the grounds on which he rested it were not sufficient to meet the demands of an impartial inquirer. Religious sentiment became blended with scientific arguments; and in the discussions which arose on the subject, the public was carried out of a strictly philosophical domain into the atmosphere of theological strife. In addition to these distinct volumes which perpetuate the author's name, there are preserved in the London Royal Society's *Transactions,* in the *Transactions* of the Royal Society of Edinburgh, in the *Reports* of the British Association, in the Library of Useful Knowledge, in the *Philosophical Magazine,* of which Brewster was an editor, and in the *North British Review,* not to mention other publications, a number of papers which proceeded from the activity of his untiring pen.

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[1] *Athenæum*, 1855.

Whilst his popularity was promoted by productions of this order, his permanent fame rests mainly on his important discoveries respecting the laws and naturo of light. And in attempting to indicate them we are met at the outset by a difficulty which has hampered us in previous sketches—the difficulty of making an abstruse subject intelligible to those who may be entirely unacquainted with it. Brewster's most brilliant studies were devoted to inquiries respecting what is termed the *polarization of light.* One of the best, because one of the clearest expositions of this subject, may be found in the writings of an American, Dr. Loomis, professor of natural philosophy in the University of New York. "If a beam of light, which has been reflected from a plate of unsilvered glass, at an angle of about 56°, be received upon a second plate of glass, similar to the former, and at the same angle of incidence, the light will be readily reflected when the two planes of incidence are parallel to each other, but will not be reflected when the two planes of incidence are perpendicular to each other. The light has therefore acquired new properties by reflection from the first plate of glass, and is called polarized light, while the modification which the light has experienced by this reflection is called polarization." "The term polarization was derived from the theory of emission" (as opposed to the theory of undulation) "and it was conceived that each luminous molecule has two poles, analogous to the poles of a magnet."

To the scientific conclusions which constitute the modern doctrine of the polarization of light, Brewster was a large contributor. He discovered that some crystals instead of giving, by double refraction, two images oppositely polarized, give a single polarized image:[1] he and M. Biot proposed tentative formulæ for the cases in which several reflections or refractions take place;[1] he found that the colours of the topaz under certain circumstances exhibited themselves in the form of elliptical rings crossed by a black bar, "the most brilliant class of phenomena in the whole range of optics.[2] He showed that glass, under compression, produced colours resembling those which are given by doubly refracting crystals;[3] and he fully examined what is termed the elliptical polarization of metals, or the effect of metals upon the light which they reflect, as different from that produced by transparent bodies; he described the modification as elliptic polarization, in doing which he seems to have been led by a desire to avoid as much as possible all reference to theory.[4] In short, to use the language of Dr. Whewell, "I may observe that the immense number and variety of the beautiful optical discoveries which we owe to Sir David Brewster, make the comparison" (a comparison with Faraday) "in his case a very imperfect representation of his triumphs over nature, and that besides his place in the history of the theory of optics, he must hold a most eminent position in the history of optical crystallography, whenever the discovery of a true optical theory of crystals supplies us with the epoch to which his labours in this field form so rich a prelude. I cordially assent to the expression employed by Mr. Airy in the *Philosophical Transactions* for 1840, in which he speaks of Sir David Brewster as 'the father of modern experimental optics.'"[5]

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[1] Whewell, *History of Inductive Sciences,* vol. ii. p. 300.

Brewster wisely distinguished between facts and theories, and whilst earnestly intent upon the former, he seems to have been somewhat shy in reference to the other. There had been before his time a sharp controversy relating to two theories of light, the *corpuscular* theory as it is sometimes called, and what is commonly termed the *undulatory* theory. Newton held the former, believing that light consisted of minute material particles, or molecular forces. They were supposed by him to be infinitesimally small, but each to have a distinct existence. The latter, the undulatory theory, wrought out by Young and Fresnel, regards light as consisting of *waves*, resembling tho motion of air. Light is thus resolved into *movement and force*, not into the existence of distinct atoms : and, without defining the nature of the transference of the energy, the advocates of the theory entertain the idea of a highly elastic fluid, provisionally, only provisionally, called *ether*, in which waves of light are propagated. Dr. Whewell applies this theory to the explanation of the periodical colours of thin plates and shadows, of double refraction, of polarization, and what is denominated depolarization.[1] But he observes, relative to Brewster, that when he was "enriching optical knowledge with so vast a train of new phenomena and laws, he shared the general aversion (at that period, 1802) to the undulatory theory, which indeed he hardly overcame thirty years later."[2]

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[1] Whewell, *History of Inductive Sciences*, vol. ii. p. 301.
[2] *Ibid.*, p. 308. [3] *Ibid.*, p. 355. [4] *Ibid.*, p. 361. [5] *Ibid.*, p. 373.

It may be added that Brewster objected to Newton's opinion, that the coloured rays, separated by refraction, are altogether simplo and homogeneous. Brewster contended that they were capable of further analysis, and found that rays passed through coloured media, blue glass for instance, were not only absorbed or transmitted in various degrees, but were also altered in their hue, which he attributed, on further experiment, to the absorption of one component colour and the transmission of the other. This was exceedingly ingenious, but Whewell treats the result as unsatisfactory.[1]

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[1] Whewell, vol. ii. pp. 322–345.

[2] *Ibid.*, p. 349.

The results of manifold optical experiments were given to the world by David Brewster in his works entitled, *On a New Analysis of Solar Light indicating three primary colours forming coincident spectra of equal length; On Circular Polarization; On the Effects of Compression and Dilatation in altering the polarizing structure of the doubly refracting crystals;* and others, "in which the law is determined which connects the refractive index of a crystal with its angle of polarization, and the discovery of rings in biaxial crystals is made known."

Brewster with his characteristic love of facts conjoined the desire of turning what he learnt to practical purposes. He preferred the useful to the speculative, and became an inventor of two kinds of instruments, very different from each other,—the one ministering to human amusement, the other to the preservation of human life.

Those of us who are advanced in years can well remember the first appearance of the kaleidoscope, and the delight with which it was welcomed. It was composed of a tube of tin, or of strong pasteboard, with a circular cell at the further end, formed by two circular glasses, one of ground glass and the other of plain glass. Into this cell were introduced beads and bits of glass of different sizes and colours, leaving room for them to shift about as the kaleidoscope was turned round. Through the length of the tube were inserted three slides of looking glass, making a triangle, and at the opposite end to that in which the fragments were placed was a circular piece of tin or pasteboard, in the middle of which a small hole was pierced, through which the eye could watch the wonders going on in the opposite pole of this optical contrivance. They were wonders, indeed, as seen by boys and girls when the whole thing was a perfect novelty; and the patterns, of inexhaustible variety, into which the shifting pieces fell afforded the utmost amusement and delight. And we perfectly recollect the joy with which we looked into one of these kaleidoscopes constructed by our own hands. We did not trouble ourselves with the question, who invented the instrument? but it is now well known that all our juvenile diversion was owing to the genius of David Brewster. He was the inventor of the kaleidoscope.

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[1] Whewell, ii. p. vol. 288.

In walking along a cliff and looking up to the windows of a lighthouse, still more clearly when ascending to the top of the building, the reader must have noticed a series of cylindrical lenses, like ribs of glass, fixed close to each other. This arrangement, through which artificial light by means of burners in the chamber of the lighthouse is easily intensified and most widely diffused, has been brought to great perfection; and is a wonderful improvement upon the earlier method of illuminating the building by means of lamps with imperfect reflectors. To the final effect Brewster was a great contributor. In 1812 he published *A Treatise on Burning Instruments, containing the method of building large polygonal lenses.* In this publication he showed that the perils of coast navigation would be considerably lessened if all lighthouses were fitted with large polygonal lenses instead of the old-fashioned dim reflectors. The lenses were to consist of central discs, with concentric zones in separate pieces constructed all round. The invention was at once taken up in France, and Fresnel brought it into use for the benefit of his own country; but it was some time before the improvement had any practical influence upon the safeguards of our own rock-bound shores. A few years after his discovery, Brewster wrote *An Account of a New System of Illumination for Lighthouses,* and he also offered his service to the Lighthouse Boards throughout the kingdom. Six years elapsed before anything was done in consequence, and then, in 1833, on the Calton Hill of Edinburgh, experiments were made, which proved that one polygonal lens, with an argand burner and four concentric circles, imparted light equal to nine parabolic reflectors, each furnished with an argand burner. From that period the new system of lighthouse illumination came into use, and ever since our seamen have had reason to bless the name of Brewster.

Science often goes unrewarded, and genius, struggling with difficulties, is crushed in the warfare of life. The story of Palissy the potter has been repeated again and again with variations in the history of gifted men, but Brewster met with a far different fate. It is remarkable how all the notices of him in our biographical dictionaries bristle luminously with lists of rewards and honours.

He repeatedly won prizes and medals from learned bodies. In 1801 he received an honorary degree of M.A. from Edinburgh; in 1807 an LL.D. from Aberdeen. In 1808 he was elected a Fellow of the Royal Society of Edinburgh, and in 1815 a Fellow of the Royal Society of London. He associated with Sir Humphrey Davy and Sir John F. W. Herschel in founding the British Association; and in 1831, after the first meeting had been held in York, William IV. conferred on Brewster the order of knightood, and the decoration of the Hanoverian Guelphic order. Thus thick and fast honours fell on him, and in 1841 he received an appointment to the principalship of St. Leonard's College in the University of St. Andrews. In that beautifully secluded city, enjoying full leisure for his scientific pursuits, with stimulus derived from the memory of distinguished philosophers interred in the cemetery under the shadow of the venerable cathedral, close to the sea, the perils of which on behalf of his sailor countrymen he had so successfully diminished, he spent laborious and useful years, until he became principal of the University of Edinburgh in 1859. He presided at one of the annual meetings of the British Association, and also took the chair at the Peace Congress in 1851. Foreign Academies placed him on their roll—Petersburgh, Berlin, Copenhagen, and Stockholm; and above all, he enjoyed the signal honour, not only of being a corresponding member of the French Academy, but of being also one of the eight foreign associates of that very learned body.

Though Brewster relinquished in early life the vocation of the ministry, it proceeded from no unbelief in the truths of Christianity, or want of interest in what relates to the Christian Church. In scientific writings, when a fair opportunity offered itself, as in his book on *More Worlds than One,* he expressed his hope as a Christian, and the spirit of religion is vividly manifest in his speculations on the future life. He looked not on mere grounds of reasoning for a future state of existence, but for that life and immortality which are brought to light by the gospel. In his *Memoirs of Newton* there are passages which bespeak the ardent believer in Divine revelation, and it is remarkable in what tones of earnestness he dwells upon the elements of evangelical faith. The following paragraph may be quoted as a specimen:

"When a mind of great and acknowledged power first directs its energies to the study of the material universe, no indications of order attract his notice, and no proofs of design call forth his admiration. In the starry firmament he sees no bodies of stupendous magnitude, and no distances of immeasurable span. The two great luminaries appear vastly inferior in magnitude to many objects around him, and the greatest distances in the heavens seem even inferior to those which his own eye can embrace on the surface of the earth. The planets, when observed with care, are seen to have a motion among the fixed stars, and to vary in their magnitudes and distances; but these changes appear to follow no law. Sometimes they move to the east, sometimes to the west, passing the meridian sometimes near and sometimes far from the horizon, while at other times they are absolutely stationary in their paths. No system, in short, appears, and no general law seems to direct their motions. By the observations and inquiries of astronomers, however, during successive ages, a regular system has been recognised in this chaos of moving bodies, and the magnitudes, distances, and revolutions of all the planets which compose it have been determined with the most extraordinary accuracy. Minds fitted and prepared for this species of inquiry are capable of appreciating the great variety of evidence by which the facts of the planetary system are established; but thousands of individuals, and many who are highly distinguished in other branches of knowledge, are incapable of understanding such researches, and view with a sceptical eye the great and irrefragable truths of astronomy.

"That the sun is stationary in the centre of our system; that the earth moves round the sun, and round its own axis; that the diameter of the earth is nearly 8,000 miles, and that of the sun *one hundred and ten* times as great; that the earth's orbit is more than 180 millions of miles in breadth; and that, if this immense space were filled with light, it would appear only like a luminous point at the nearest fixed star,—are positions absolutely unintelligible and incredible to all who have not carefully studied the subject. To millions of our species, then, the great book of nature is absolutely sealed, though it is in the power of all to unfold its pages, and to peruse those glowing passages which proclaim the power and wisdom of its Author. The book of revelation exhibits to us the same peculiarities as that of nature. To the ordinary eye it presents no immediate indications of its Divine origin. Events apparently insignificant, supernatural interferences seemingly unnecessary, doctrines almost contradictory, and prophecies nearly unintelligible occupy its pages.

The history of the fall of man, of the introduction of moral and physical evil, the prediction of a Messiah, the advent of our Saviour, His precepts, His miracles, His death, His resurrection, the gift of tongues, and the subsequent propagation of His religion by the unlettered fishermen of Galilee, are each a stumbling-block to the wisdom of this world. The youthful and vigorous mind, when summoned from its early studies to peruse the Scriptures, turns from them with disappointment. It recognises in them no profound science, no secular wisdom, no Divine eloquence, no disclosures of nature's secrets, no palpable impress of an Almighty hand. But, though the system of revealed truth which the Scriptures contain is, like that of the universe, concealed from common observation, yet the labours of centuries have established its Divine origin, and developed in all its order and beauty the great plan of human restoration. In the chaos of its incidents we discover the whole history of our species, whether it is delineated in events that are past, or shadowed forth in those which are to come,—from the creation of man and the origin of evil, to the extinction of his earthly dynasty, and the commencement of his immortal career.

"The antiquity and authenticity of the books which compose the sacred canon,—the fulfilment of its prophecies, the miraculous works of its Founder, His death and resurrection, have been demonstrated to all who are capable of appreciating the force of historical evidence; and in the poetical and prose compositions of the inspired authors we discover a system of doctrine, and a code of morality, traced in characters as distinct and legible as the most unerring truths in the material world. False systems of religion have indeed been deduced from the sacred record, as false systems of the universe have sprung from the study of the book of nature; but the very prevalence of a false system proves the existence of one that is true, and though the two classes of facts necessarily depend on different kinds of evidence, yet we scruple not to say that the Copernican system is not more demonstrably true than the system of theological truth contained in the Bible. If men of high powers, then, are still found who are insensible to the evidence which has established the system of the universe, need we wonder that there are others whose minds are shut against the effulgent evidence which sustains the strongholds of our faith?"[1]

Proceeding from the pen of an eminent natural philosopher, the passage is adapted to impress those who will not listen to the arguments of professional divines. The analogy between nature and revelation, with reference to the wonders *concealed* in the bosom of each—wonders not to be understood and appreciated without careful study—is put with force, and deserves the attention of scientific students, who, while they feel the need of laborious investigation for anything like a fair knowledge of the laws of light or any other physical phenomenon, seem to fancy that a cursory glance at the contents of Scripture is quite sufficient to qualify them for all kinds of negative criticism, and for dogmatic denials, relative to the doctrines of Christianity. The cautious habits of Brewster's mind would preserve him from adopting principles for which he did not perceive adequate reasons; and reasons deemed adequate by such a man are not to be hastily set aside. In him we have an illustrious example of what some amongst us seem to deem incongruous, if not impossible—that is to say, a thorough mastery of modern science, and a firm attachment to evangelical beliefs. His biography shows that neither, on the one hand, does philosophical culture unfit a man for the simplicity of Christian faith; nor, on the other hand, does simple Christian faith create any prejudice against philosophical culture. Indeed, in his case they appear as mutual helpers: Christian faith sanctifying the researches of philosophical reason, and philosophical reason tendering its services to Christian faith. And this is very remarkable, that it is not a cold dry assent to orthodox dogmas which we find in the writings of Brewster, but a hearty concurrence with the truths of revelation, and an impassioned advocacy of their claims upon the acceptance and obedience of mankind.

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[1] *Life of Sir I. Newton*, p. 262.

Towards the close of life he seems to have ripened for another world. "'Night after night,' says Mrs. Gordon, 'the Word of God was brought from its place and studied with commentaries and notes, even as in the early days. If ever there was a seeking of God with "strong crying and tears," it was by Brewster at this time. Frequently in the earliest morning, when the writing, and the microscope, and the Bible-reading were over, have I been awakened to listen in awe to the sounds of prayer and weeping below.' It was about this time, in 1856, that, in a conversation with his daughter-in-law, he expressed his sense of the impossibility of loving God. Reverence, even trust, he could understand. 'But how can we love

Him, One whom we have not seen?' His daughter-in-law entirely agreed with him; but afterwards coming to know the love of Christ, she had learned to love Him, and thought it her duty to tell him of her changed experience.

"'He listened most attentively,' she says, 'and when I had finished, took me in his arms, kissed me, and said in such a childlike manner, "Go now, then, and pray that I may know it too."' Such simplicity and earnestness in seeking never fail to find. Peace came to him at last, as it comes to all, in simply believing. 'The atonement,' he said to us, about a year before his death, and after many years' experience, 'oh, it is everything to me; it meets my reason, it satisfies my conscience, it fills my heart.' He was then very poorly, and, as we thought, believed himself dying. It was but rarely, however, that he spoke of himself or his feelings. But he was never weary in speaking or hearing of God's work in our own or other lands. His voice would falter, and his eye be suffused with a tearful film, when the conversation turned on revivals or striking cases of conversion. On the third day before his death he had been very busy, and at last seemed to feel that everything was done, all ready, and arranged. In the afternoon he saw his pastor, the writer of the present reminiscences. 'My race is run,' he said, and there was something of the old scientific habit in what he added: 'from the palpable failure of strength from one day to another, I feel as if I could count the very day on which all must close.' There was a great calm and awful solemnity in his aspect. He spoke with deep feeling and tenderness of the happiness he had enjoyed in life. 'Never man,' he said, 'had more cause for thankfulness than I; but, with all that, now that I can be of no use either to myself or any one else, I have no wish to linger here.' Some reference was made to a former conversation on the atonement. 'Oh yes,' he said, 'the orthodox doctrine of the Church is my faith, and it gives me perfect peace in resting on it now.' He expressed his wonder at the difficulties some good men seemed to feel in receiving it as worthy of God: for himself, he had none. He felt perfect peace in relying upon Jesus, in the certain prospect of standing very soon in the immediate presence of God. For the last day or two he was attended by his friend, Sir James Simpson, a man of kindred genius and of kindred Christian hopes. 'The like of this I never saw,' he said, as we met him coming fresh from the dying chamber. 'There is Sir David resting like a little child on Jesus, and speaking as if in a few hours he will get all his problems solved by Him.' For in that supreme hour of dawning immortality his past studies were all associated with the name and person of the Redeemer. 'I shall SEE JESUS,' he said, 'and that will be grand. I shall see Him who made the worlds,' with allusion to those wonderful verses in Hebrews, which had formed the subject of the last sermon he ever heard, a few weeks before. Thus, tracing all to the Creator Redeemer, he felt no incongruity, even in these hours, in describing to Sir James Simpson in a 'fluent stream of well-chosen words' some beautiful phenomena in his favourite science. Reference was made to the privilege he had enjoyed in throwing light upon the 'great and marvellous works of God.' 'Yes,' he said, 'I found them to be great and marvellous, and I felt them to be His.' He had little pain but such as came from intense weakness. The light was with him all through the valley. 'I have had the light for many years,' he whispered, slowly, and with emphasis; 'and oh, how bright it is! I feel SO SAFE, SO SATISFIED.' And so in childlike reliance and adoring love he gently fell asleep in Jesus, on the evening of Monday, 10th February, 1868. On the Saturday following he was laid beside kindred dust. Never since the Great Minstrel of the Border was borne from Abbotsford to Dryburgh Abbey has the valley of the Tweed been so moved as when, followed by the gowned representatives of the University and various scientific societies, through the midst of a wistful multitude, the sage of Allerly was laid amidst the precincts of the good old Abbey of Melrose.

"Those visiting the tomb find on it the inscription, so simple and appropriate—

'The Lord is my Light.'"[1]

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[1] *Leisure Hour* for 1868, p. 325.

JOHN F. W. HERSCHEL.

1792–1871.

THE name of Herschel is identified with astronomy. The lustre of the father's renown, as an observer, is only surpassed by that of the son, who continued his father's work, and, from the advantages of an university education, was enabled to carry the philosophy of the universe beyond what old Sir William, with limited culture, could possibly reach.

William Herschel came from Hanover to England in the middle of the last century. He distinguished himself as a musician, and obtained an engagement as organist at Halifax, after which he removed to a more lucrative position of the same kind at Bath. There he manifested a taste for the science he was destined to adorn, and there he wrote "Astronomical Observations of the Periodical Star *Mira Ceti*," also "Observations Relating to the Mountains of the Moon," both of which papers were read before the Royal Society in 1780. His discovery of the planet Uranus, in 1781, raised him to eminence. His sister, Caroline Lucretia, who joined him when he was living at Bath, there began those services which have united her name with his in the annals of astronomy. Day and night she with him watched the heavens, and helped him to record the results; also, on removing to Datchet, and then to Slough, they pursued together their philosophical toils. At Slough was erected the great telescope, which we well remember, in the garden of the old red brick house, so familiar to those who passed that way, and there she and her brother swept the heavens in search of comets and new stars, which were carefully inserted in the catalogue they made.[1]

So closely connected were the labours of the father and those of the son, JOHN FREDERICK WILLIAM, that the life of the one is scarcely complete without the life of the other.

The son was born at Slough, in 1792, and was educated at St. John's College, Cambridge. He graduated as senior wrangler in 1813, and presently wrote for the Royal Society a paper "On a Remarkable Appearance of Cotes' Theorem." In the same year he was elected fellow. Having confined himself at first to pure mathematics, he, at his father's death in 1822, caught his father's mantle, devoting himself to those astronomical observations of which he had, in his father's house, such brilliant examples. He carefully noted the angular distances and positions of the double and triple luminaries, and the position of nebulæ and stellar clusters. As the result he published, at intervals, six catalogues of double stars, varying from 284 to 2,007 each. The difficulty of carrying on such a course of observations is very great. A clear sky and a calm atmosphere are indispensable conditions of success, and these generally occur in the hours between midnight and sunrise rather than at other periods. In the winter, an hour before midnight is often a good time for getting a clear view. Consequently the night work thus entailed was immense, and severely tried the health and strength of the observer, who, in reference to his labours, made the following remark:—"Should I be fortunate enough to bring this work to a conclusion, I shall then joyfully yield up a subject on which I have bestowed a large portion of my time, and expended much of my health and strength, to others, who will hereafter, by the aid of those master-pieces of workmanship which modern art places at their disposal, pursue with comparative ease and convenience an inquiry which has presented to myself difficulties such as at one period had almost compelled me to abandon it in despair."[1] Mapping out the sidereal heavens, and cataloguing the stars formed the speciality of Herschel's practical scientific career. Thus he perfected what had been begun by his indefatigable father and aunt. The phenomena in the heavens were by the same astronomer described as well as enumerated, and with the skill of an artist he accurately and delicately depicted every extraordinary appearance in the celestial bodies. In reference to this part of his work, it is said, "The peculiarities represented cannot be described by words or by numerical expressions. These drawings contain that which is conspicuous and distinctive to the eye, and that which will enable the eyes of future observers to examine whether secular variation is perceptible. They are, in fact, the most distinct and most certain records of the state of a nebula at any given time."[1]

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[1] See the interesting *Memoir and Correspondence of Caroline Herschel.*

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[1] Quoted in *Leisure Hour*, 1865, p. 632.

Slough was the post of observation where Herschel in late summer evenings and early winter mornings made his unexampled surveys. But there he could command a perfect prospect of the northern hemisphere alone; of the southern hemisphere he could see little. It is no cause of wonder then, that, having read so carefully one part of the heavens, he should wish to study the other. Accordingly, in 1833, he undertook a voyage to the Cape to carry on explorations in the southern field of stars. He embarked in November, and reached his destination the January following. He engaged a house six miles from Cape Town, and there, within an enclosure of trees, erected a telescope of great magnitude, constructed on the best modern plan. There he continued his catalogue, and there he delineated particular objects with characteristic correctness and beauty. The celebrated nebula in the handle of Orion's sword, much more magnificent when seen in southern latitudes than it ever comes out in northern climes, is said to be represented with the greatest care and effect. The variable star, *Eta Argus*, is also admirably depicted, and certain portions of the Milky Way are presented in a beautiful manner.

Measures of the distances of double stars, and a determination of the relative brightness of orbs, also formed subjects of study, together with the appearance of Halley's comet, the satellites of Saturn, and the solar spots visible at the close of 1836 and the beginning of 1837. We are told that on the 25th of May, 1837, an extraordinary spot was seen on the sun's disc, and Herschel calculated that the black centre was large enough to have allowed our globe to drop through, leaving a thousand miles space all round between it and the edge of the tremendous gulf.

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[1] Astronomer Royal, on presenting the gold medal to Captain Smyth for Sir J. F. W. Herschel.

As the fruit of the laborious investigations carried on at Slough, and in the neighbourhood of Cape Town, Herschel prepared an enlarged catalogue of nebulæ and clusters. It contains all the nebulæ and clusters which have been anywhere described and identified, so as to warrant their taking a place in his inventory. The number of objects amounts to 5,078, including all noticed by his father, the Earl of Rosse, and others, as well as himself.

Other scientific subjects besides astronomy occupied the attention of this minute and yet comprehensive philosopher. Mathematics were his *forte*, and to them, in their higher branches, he made valuable contributions. Optics, as might be expected, in connexion with astronomy, engaged his thoughts. Geology and chemistry likewise came within the range of his inquiries, and he discussed theories of light and sound. The *Encylopædia Britannica*, and the *Transactions* of the Royal Society, bear witness to his scientific genius and industry.

It is scarcely needful to mention that medals, titles, and honours flowed in abundantly upon so distinguished a person, and amongst them were a knighthood conferred by King William IV., and a baronetcy by Queen Victoria. He was president of the Royal Astronomical Society three times, and presided at the meeting of the British Association for the Advancement of Science held at Cambridge.

It is interesting to notice that the mastership of the Mint, held by Sir Isaac Newton, was an office bestowed on Herschel in 1851. In the interval it had been held by some political personage, member of the House of Commons; but the political character of the appointment ceased from the date just given. In four years the philosopher resigned this post, and retired into private life, spending the remainder of his days at Collingwood, near Hawkhurst, in the county of Kent. Even in this very brief sketch of his active life it would be unpardonable to omit all reference to his efforts for the improvement and extension of popular education. We well remember his acceptance of the presidency of a self-improvement society at Eton, with which we had the honour to be connected. Nor can we forget his communications with the committee and members, and the beautiful lecture on "The Pleasures and Advantages of Reading," which he delivered when the institution was first formed.

Sir J. F. W. Herschel was not merely a man of science. He had a keen taste for the delights of literature, and in the latter department he excelled as he did in the former. Hitherto we have noticed only his mathematical attainments, his astronomical discoveries, and his intimate acquaintance with philosophical subjects in general. Now we are to consider him as an eminent contributor to the literature of philosophy. His manner of handling scientific themes is beyond all praise. Equally removed on the one hand from superficiality of thought and floridness of diction, and on the other hand from a pedantic method and a crabbed style, he had the happy art of presenting the most profound truths in a simple and intelligible form, and of clothing his ideas, whether subtle or comprehensive, in language equally chaste and dignified. The two works by which he is so well known, his *Treatise on Astronomy* and his *Discourse on the Study of Natural Philosophy*, are remarkable alike for their scientific and literary excellence.

The first of these publications treats of geography, uranography, the sun's motion, the solar system, satellites, comets, perturbations, sidereal astronomy, and the calendar. All these topics are lighted up in the most attractive manner, and the author's instructions, though mainly intended for those who have some elementary mathematical knowledge, are so conveyed as to interest and inform the unlearned reader. It is rare indeed to find any one who can so combine severe scientific statement and reasoning with familiar and popular ways of illustration. And this too is very remarkable, that, without departing from his chosen line of observation, he sheds radiance over the widest fields of truth, and, whilst guiding the student in a particular path, he helps him to form habits of the greatest use in other pursuits. The opening paragraphs of his treatise deserve the careful attention of every one.

The reader is directed to that kind of intellectual discipline which is of the highest service in all moral as well as scientific studies. The mind must be watchful against *all* prejudices. It must be prepared to accept whatever comes recommended by adequate evidence. The mental eye must be purged, and the eyelids must not be closed from the sight of objects unexpected or deemed uninviting. The surprises which await the young astronomer are analogous to surprises awaiting the inquirer after moral and religious truth. Unanticipated conclusions may force themselves upon the mind of the moral philosopher and the Christian theologian before they have proceeded far in their respective pursuits. The lesson, which few will reject in the abstract, is susceptible of many-sided applications. Undoubtedly it supplies a caution to those who are accustomed to what may be termed *orthodox* habits of thought, lest they should reject what they are at first, but on insufficient grounds, tempted to regard as inconsistent with revealed truths. But, at the same time, it cautions with equal emphasis those who are addicted to what may be termed *heterodox* habits, against assuming that religious convictions, which they must be conscious they dislike, are unsupported by evidence, and that things which the most accomplished Christian philosophers have found in Holy Scripture, are utterly impossible.[1] It needs to be repeated again and again, that maxims commonly pointed in a certain direction ought also to be pointed in another and opposite one.

Herschel's *Discourse on the Study of Natural Philosophy* would have been worthy of Lord Bacon. We are afraid that it is by no means so well known and so generally and carefully studied by thoughtful young people as it deserves to be. It treats of the general nature and advantages of the study of physical science, of the principles on which physical science relies for its successful prosecution, and the rules by which a systematic examination of nature should be conducted, with illustrations of this influence as exemplified in the history of its progress, and of the subdivisions of physics into distinct branches, and their mutual relations. All these subjects are discussed under the illumination of comprehensive knowledge, with a clear insight into the nature and bearings of the diversified subjects embraced in such a discourse, and in methods of thought and expression as lucid as they are forcible, and as beautiful as they are just.

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[1] See extract on page 312.

Every now and then the author discloses to us his religious convictions, and these it is now proper for us to gather up.

1. He shrinks not from recognising what now is doubted, if not denied, in some scientific quarters, the evidence of intelligence and power in the works of nature. "Independent of the pleasures of fancy and imagination, and social converse, man is constituted a speculative being. He contemplates the world and the objects around him, not with a passive indifferent gaze, as a set of phenomena in which he has no further interest than as they affect his immediate situation and can be rendered subservient to his comfort, but a system, disposed with order and design." "He is led to the conception of a power and intelligence superior to his own, and adequate to the production and maintenance of all that he sees in nature,—a power and intelligence to which he may well apply the term infinite, since he not only sees no actual limit to the instances in which they are manifested, but finds, on the contrary, that the further he inquires, and the wider his sphere of observation extends, they continually open upon him in increasing abundance; and that as the

study of one prepares him to understand and appreciate another, refinement follows on refinement, wonder on wonder, till his faculties become bewildered in admiration, and his intellect falls back on itself in utter hopelessness of arriving at an end." [1]

2. With regard to a future state, Herschel makes some very pertinent and weighty observations. Proceeding from a notice of external objects in reference to a supreme intelligence and power, he refers to man's own vital and intellectual faculties,—to a world within him, abounding with phenomena and relations of the highest immediate interest, and thus proceeds: "While he cannot help perceiving that the insight he is able to obtain into this internal sphere of thought and feeling is in reality the source of all his power, the very fountain of his predominance over external nature; he yet feels himself capable of entering only very imperfectly into these recesses of his own bosom, and analysing the operations of his mind—in this, as in all other things, in short, '*a being darkly wise;*' seeing that all the longest life and most vigorous intellect can give him power to discover by his own research, or time to know by availing himself of that of others, serves only to place him on the very frontier of knowledge, and afford a distant glimpse of boundless realms beyond, where no human thought has penetrated, but which yet he is sure must be no less familiarly known to that intelligence which he traces throughout creation than the most obvious truths which he himself daily applies to his most trifling purposes. Is it wonderful that a being so constituted should first encour-

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[1] *Discourse*, pp. 4, 5.

age a hope, and by degrees acknowledge an assurance, that his intellectual existence will not terminate with the dissolution of his corporeal frame, but rather that in a future state of being, disencumbered of a thousand obstructions which his present situation throws in his way, endowed with acuter senses and higher faculties, he shall drink deep at that fountain of beneficent wisdom, for which the slightest taste obtained on earth has given him the keenest relish?"[1]

3. The moral influence of true science is beautifully described in the following passages: "There is something in the contemplation of general laws which powerfully persuades us to merge individual feeling, and to commit ourselves unreservedly to their disposal, while the observation of the calm energetic regularity of nature, the immense scale of her operations, and the certainty with which her ends are attained, tends irresistibly to tranquilize and reassure the mind, and render it less accessible to repining, selfish, and turbulent emotions. And this it does, not by debasing our nature into weak compliances and abject submission to circumstances, but by filling us, as from an inward spring, with a sense of nobleness and power, which enables us to rise superior to them; by showing us our strength and innate dignity, and by calling upon us for the exercise of those powers and faculties by which we are susceptible of the comprehension of so much greatness, and which form, as it were, a link between ourselves and the best and noblest benefactors of our species, with whom we hold communion in thoughts, and participate in discoveries which have raised them

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[1] *Discourse*, p. 7.

above their fellow mortals, and brought them nearer to their Creator."[1]

4. The relation of science to religion comes into view at an early part of the discourse, and he thus vindicates true philosophy from the charge of an irreligious tendency: "Nothing then can be more unfounded than the objection which has been taken *in limine*, by persons well meaning perhaps, certainly narrow minded, against the study of natural philosophy, and indeed against all science—that it fosters in its cultivators an undue and overweening self-conceit, leaves them to doubt the immortality of the soul, and to scoff at revealed religion. Its natural effect, we may confidently assert, on every well constituted mind, is and must be the direct contrary. No doubt the testimony of natural reason, on whatever exercised, must of necessity stop short of those truths which it is the object of revelation to make known; but, while it places the existence and principal attributes of a Deity on such grounds as to render doubt absurd, and atheism ridiculous, it unquestionably opposes no natural or necessary obstacle to further progress: on the contrary, by cherishing as a vital principle an unbounded spirit of inquiry and ardency of expectation, it unfetters the mind from prejudices of every kind, and leaves it open and free to every impression of a higher nature, which it is susceptible of receiving, guarding only against enthusiasm and self-deception by a habit of strict investigation, but encouraging rather than repressing everything which can offer a prospect or a hope beyond the present

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[1] *Discourse*, p. 16.

obscure and unsatisfactory state. *The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable.*"[1] The connexion in which this last golden sentence stands, makes it doubly precious. But he wisely cautions religious people against a hasty and rash application of facts to the interpretation or illustration of Scripture. Science, when kept within its natural bounds of physical and intellectual inquiry, can never run counter to sound principles of moral philosophy, or the doctrines of the New Testament. Immorality and impiety on the one hand, and on the other a humble patient spirit of inquiry into the wonders of the world without and of the world within, must ever be essentially opposed to each other. So also Christian faith, the reverence due to Divine revelation, and submission to the gracious authority of the Lord Jesus Christ, as the Redeemer and Regenerator of human souls, can never reasonably be made antagonistic to such a method of scientific study as is illustrated and enforced in the volume just described.

Herschel lived a long and honoured life, and died in May, 1871, lamented by every one. He was interred in Westminster Abbey, and on the Sunday after the funeral Dean Stanley preached an appropriate sermon, in which he appropriately remarked:—"'Born under the giant shadow of his illustrious father's telescope,' inheriting from him his aspiring tastes and his unconquerable genius, the stars from his earliest years were his constant companions. 'Light,' he used to say, 'was his first love.' For him was reserved that task which the Book of Job describes as of superhuman magnitude, the exploration for the first time of 'the wonders without number,' not only in the familiar regions of the north, but in the secret chambers of the south; that southern hemisphere whose marvels he has himself so eloquently described, 'where a new heaven as well as a new earth is laid open to the gaze of the astronomer, a celestial surface equal to the fourth part of the heavens; the vivid beauty of the Southern Cross sung by poets, and celebrated by the pen of the most accomplished of civilized travellers;' the constellations which neither Moses, nor David, nor Galileo, nor Newton ever saw, but which shall look down on the future destinies of the teeming nations of the youngest born of the families of earth."[1]

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[1] *Discourse*, p. 7.

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[1] *Good Words*, July, 1871.

ADAM SEDGWICK.

1787–1873.

THE University of Cambridge has long been celebrated for scientific students. In the seventeenth century it took a start in this direction, which it has followed ever since. The pre-eminent attention which is paid in its schools to mathematical pursuits renders it in the highest degree a place of education favourable to the training of men eager to devote themselves to the acquisition of physical as well as literary knowledge. Hence it has produced a number of philosophers whose names are celebrated throughout the world. Dr. Barrow, Sir Isaac Newton, and Sir J. F. W. Herschel, of whom sketches have been given in this volume—all three, not to mention many others, were proud to acknowledge Cambridge as their *alma mater;* and now we have to add a fourth scientific celebrity whose genius was nursed and developed on the banks of the Cam.

ADAM SEDGWICK was born at Dent, in Yorkshire, in the year 1784, and he took a position in 1808 as fifth wrangler in his university. He became Fellow of Trinity in 1810, and Woodwardian professor of geology in 1818. Attracting the attention and inspiring the confidence of the late Prince Consort by his ability, attainments, and personal virtues, he acted as University Secretary to His Royal Highness, whilst he was holding the office of chancellor; and it is well known that he enjoyed the friendship of the Royal Family in the highest degree, and made himself a favourite with the young princes and princesses, in whose sports and pastimes he condescended to share. As a clergyman of the Church of England he enjoyed a stall in Norwich Cathedral; and to the end of life, when not engaged in university vocations, he dwelt in a prebendal home within the pleasant Close of the old East Anglian city. We remember at an afternoon service when he was in residence, being struck with his impressive appearance, his manly cheerful countenance, and the earnest solemn manner in which he read the lessons, though, owing to the dimness of the light, and the seeming imperfection of his spectacles, he found it difficult to get through the chapters.

Geology was the favourite study and the great *forte* of Adam Sedgwick. When he first adopted it as a pursuit, he had difficulties to contend with such as it is now almost impossible to estimate. The science was in its infancy, beset by prejudices within and without. Some embraced it with enthusiasm, and, possessing only a scanty knowledge of its facts, hastily rushed into sweeping generalizations, constructing theories without any adequate basis. Inferences were drawn unfriendly to the teachings of the Bible; and, on the other hand, hypotheses of all kinds were woven to bring together the doctrines of the science and the narratives of Scripture. Whilst geological students were thus laying themselves open to unfavourable criticism, students of another description outside regarded with aversion the whole affair, treating the study with contempt, or pronouncing it positively impious. Some books written on the subject within the past half-century are among the startling curiosities of our literature, and it is painful to recall the ignorance, the presumption, and the animosity which they display. In Sedgwick's vigorous and comprehensive mind, his mathematical attainments, his acquaintance with physical science, his thorough-going habits of inquiry, his capacity for bodily endurance, his fondness for an active life, his keen powers of observation, his quickness in combining fact with fact, and in perceiving both resemblances and differences between them, his good English common sense, and, besides all the rest, the enthusiasm of his nature;—these qualities eminently fitted him to take in hand the new science, and to build it up on strong foundations. "Geology needed," says the president of the Royal Society in 1863, when awarding to Sedgwick the Copley medal, "Geology needed the support and open advocacy of men who by their intellect and acquirements, and by the respect attached to their individual character, their profession, or social position, might be able, on the one hand, to repress wild fancies, and on the other, to rebut the unfounded assertion of those who opposed the discussion of scientific truth. Such a man was Professor Sedgwick, and such was the influence he exerted." There were plenty of book-made geologists, who delighted in expatiating amidst Vulcanist and Neptunist theories—who praised or attacked Werner, who followed or opposed Hutton. They had the scantiest practical information, and had perhaps never examined a rock or a fossil in their lives, but they were conceited in their pretensions, and very dogmatical in their conclusions. Sedgwick took up geology in quite another way. He would examine nature for himself. He would go out into the fields and look at mountains with his own eyes, and examine zoological remains with his own hand. So, equipping himself for long and laborious journeys, he went forth with his hammer, and other simple helps, to see what the hills were made of, to find what treasures they contained, to mark their configuration, to follow their sweep, and to classify their manifold constituents of layers.

No sooner was he seated in the chair of geology at Cambridge, than he commenced his field labours. He at once struck for the most forbidding-looking portion of the science, that which was loosely described under the uneuphonious term of "Grauwacke." He attacked grauwacke at its supposed base in Cornwall, its supposed centre in Wales, its supposed summit in the Lake District, and for ever abolished it. He added to science the development of a long series of successive and distinct works of the Creator. In 1819 he explored Cornwall, and communicated his conclusions to the Cambridge Philosophical Society in 1820. This was the first of thirty-two separate memoirs with which he lived to enrich his chosen study. He then saw and announced that the fossils of the Plymouth limestone could not be classed with those of the mountain limestone around his early home; and this was the commencement of the separation, mainly effected by his means, of a vast group of rocks from the carboniferous above and older slaty rocks below, having a distinct life-series, and now known all over the world as the Devonian system. To this he gave his chief attention, in actual exploration and in memoirs published by various societies, until 1839, when, by the crowning work of Sir Roderick Murchison and himself, the question was settled. In this instance Murchison only glanced at the country under the guidance of his friend, and confirmed his results. The enthusiasm with which, amid opposition and difficulty, he pulled, as it were, a whole new system out of obscurity can hardly now be conceived. It was the formation time of the science. Lyall was dissecting the tertiaries, and Sedgwick unravelling the older rocks, and the wonders of the past were being increased every day. At successive meetings of the British Association, with a force of language and of mind, a grasp of phenomena and a flash of humour unrivalled, he expounded these discoveries, and, after all his demonstrations, he invariably laid the tribute of admiration and of personal veneration before the altar of God. Concurrently with this he thoroughly examined and described the rugged vales and moors of his beloved Cumbria, including Teesdale, and with a master hand placed in true position the dislocated mountain-masses of strata there. He spent the summers of 1822, 1823, and 1824 among the mountains of this district, and described them in memoirs to the Geological Society in 1831, in essays which are models of felicitous diagnosis, if so the process may be termed. His researches on the strike of the great masses did not prevent his investigating their minuter phenomena. On the contrary, he was the first to detect and describe philosophically the *cleavage, i.e.* the intimate division of slate rocks, a division not coincident with the bedding or original plan of deposition, but superinduced by some subsequent force. This has been a most useful addition to knowledge, for the commercial value of slate depends on it, and the angle of cleavage is found to indicate the quality of the rock. This discovery is announced in his paper read before the Geological Society in 1835, entitled "Remarks on the Structure of large Mineral Masses, and especially on the chemical changes produced in the aggregation of stratified rocks during different periods after their deposition."

The next great work of Sedgwick was effected in partnership with Sir Roderick Murchison. The two chiefs determined to make a joint attack on the chaotic mountains of the Principality, where Giant Grauwacke still reigned supreme. They went separately to the work, Murchison at the upper end, the border-land; Sedgwick on the very crest of the western mountains. There issued from this campaign a series of memoirs by both the captains, resulting ultimately in the establishment of the Silurian system by Murchison, and the Cambrian by Sedgwick,—dividing between them all the country from Carnarvonshire to the English border, and characterizing the rocks so happily, as to render the names and characters part of the vocabulary of science all over the world. In giving names to the strata thus disentangled, the great observers unhappily worked separately. Sir Roderick invented the term Silurian, and published it as including rocks which Sedgwick had already first investigated and named Cambrian. Hence the Silurian system of the one transgressed on the Cambrian of the other. Sedgwick considered that by the honourable law of discovery he was entitled to claim, as in his Cambrian, all rocks from the Bala limestone downwards, and he divided his conquest into lower, middle, and upper. Of these groups Murchison included and published all but the lower as Silurian, thus claiming the scientific renown and nomenclature pertaining to them. Hence the only shadow that ever dimmed the public life of the Cambridge professor. He wept his lost upper Cambrians as constantly as ever classic shepherd did his strayed and stolen flock, and for many years he uttered his complaints. Ultimately the natural history fact was ascertained to be that the natural division is not exactly where either of the illustrious pioneers had placed it. Substantially the classification of these strata into the two great divisions remains. Murchison reigns over a vast variety of sediments typified in Wales, but prevalent in most countries, whilst Sedgwick holds his throne on rugged rocks, also represented in all quarters of the globe, descending to the primeval formations.

Belgium and the Rhine, Sedgwick studied in concert with his friend Sir Roderick, carefully examining the palæozoic formations amidst the romantic scenery of those hills, valleys, and vine-clad banks so familiar to tourists in the present day. The two companions in this scientific pilgrimage also explored a part of Switzerland, and published a memoir "On the Structure of the Eastern Alps."

Sedgwick's geological studies were remarkable for their comprehensiveness and harmony. No one-sided man, he looked at a subject under different aspects, according to its diversified nature. Some geologists had investigated the mineral constituents of various strata, but had been too neglectful of fossil remains. Others, again, had fixed their attention almost exclusively on the latter, and had little, if at all, regarded the former. Sedgwick sought after both, and in his conclusions took both into account. He always advocated the principle, in conformity with which he carried on his toils, that the structure of a complicated district could never be accurately determined by fossils alone, without a minute inquiry into its stratification; nor was he misled, as some have been, by his mineralogical knowledge, to undervalue principles of classification derived from organic remains.

Mathematics were of essential service in his explorations. He attended to what has been called *mountain geometry*, "that geometry by which we unite in imagination lines and surfaces observed in one part of a complicated mountain or district, with those in another, so as to form a distinct geometrical conception of the arrangement of the intervening masses." "We think it extremely doubtful," says the President of the Royal Society in 1863, "whether any other British geologist, forty years ago, could have undertaken, with a fair chance of success, the great and difficult work which he accomplished."

Another important service already mentioned rendered by him to the interests of science is thus referred to by Dr. Pye Smith, himself a zealous geologist, and an intense admirer of Sedgwick: "The earliest slate rocks, like all other strata, must have been originally deposited in a position horizontal or nearly so. By subsequent movements, not one but evidently many, they have been raised to all elevations, and bent to the utmost extent of contortion, as is shown by the lines of stratification. But there is another kind of division, first brought to light by Professor Sedgwick, that of lines of *cleavage* and intersecting joints, or, called by a general term, structural or divisional planes. These are productive of signal benefit to the arts and convenience of man, but they involve profound geological and mathematical researches, and their causes can be explored only by going into the deepest night of terrestrial antiquity."[1]

Another remarkable excellence in Sedgwick's researches was the intimate relation into which he brought together geological phenomena from different parts. The connexion between the Devonian slates and the old red sandstone of Scotland, which he pointed out, we have mentioned already. But much further did his discovered resemblances extend. "According to him the new red sandstone of England, considered as one great complex formation, may be divided into seven members, composed of sandstones, limestones, and marls." These represent respectively formations in Germany, indicated by German names. "Such a coincidence in the subdivisions of two distant mechanical deposits, even upon the supposition of their being strictly contemporaneous, is truly astonishing. It has not been assumed hypothetically, but is the fair result of the facts which are recorded by Sedgwick."[2] No one did so much as he did to place the geological formations of England and Germany in their true relation to each other. Before his time great mistakes were made on the subject. "From the first promulgation of the Wernerian system, attempts were made to identify the English with the German members of the geological alphabet, but it was long before this alphabet was rightly read." Sedgwick was the first to read it himself and teach others to read it.

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[1] *Scripture and Geology*, p. 307.

[2] *Geological Transactions* (second series), vol. iii. p. 121.

In short, the benefits he conferred were of the highest importance and value, and testimony to them as regards his explorations in this country is thus given by his friend, Dr. Whewell, in his address as President of the Geological Society in 1839: "The classification of the rocks of this portion of our island (the Cambrian), to which Professor Sedgwick has been led, is the fruit of the vigorous and obstinate struggles of many years to mould into system a portion of geology which appeared almost too refractory for the philosopher's hand, and which Professor Sedgwick grappled with the more resolutely in proportion as others shrank away from the task, perplexed and wearied. A series of formations have been distinguished and reduced to order by indefatigable exertions and wide views," in which "it has been necessary to employ and improve all the best methods of geological investigation." Thus "he has traced the geographical continuity of the strata almost mile by mile from Cape Wrath to the Land's End."

But the merits of Sedgwick must not be estimated by his explorations only. He took a deep interest in his lectures and in the geological museum of his university, ever increasing by his own contributions the nucleus which had been formed by Dr. Woodward's collection. Thousands of specimens of rocks and of organic remains were gathered by him and conveyed to Cambridge, and for forty years and more he was indefatigable in matters connected with their arrangement. As a scientific lecturer he seems to have been singularly effective. "It is not only by written documents," to quote once more from the address on presenting the Copley medal, "that knowledge and a taste for its acquirements are disseminated; and those who have had the good fortune to attend Professor Sedgwick's lectures, or may have enjoyed social intercourse with him, will testify to the charm and interest he frequently gives to geology by the happy mixture of playful elucidation of the subject, with the graver and eloquent exposition of the higher principles and objects. Moreover, his cheerfulness and ardent enthusiasm made him a great favourite with the members of the Royal and the Geological Societies, and of the British Association. Their meetings he attended, their discussions he sustained, and he was alike valued as guide, philosopher, and friend."

We are able to adduce a valuable incidental notice of his college days, contained in a communication to the *Sunday at Home* for August, 1879.

"A few years before Professor Sedgwick's death I was led to ask him for information about two remarkable men of the past whom, as I knew, he well remembered—Henry Kirke White, and the Rev. Robert Hall. Kirke White died (in his second year at St. John's) in 1806; Robert Hall in 1836. Both were more or less connected with Cambridge, and Sedgwick's long memory covered both their distant dates. The fulness and painstaking kindness of his reply to my inquiry will be better appreciated if I first say that the recipient of the letter, myself, was just *fifty-six years* junior in academic standing to the writer, and had been kept, by non-residence in college, out of the way of personal intercourse with him.

"'——, *Dec.* 16, 1868.

"'MY DEAR SIR,—

"'I wish it were in my power to give you more information respecting the two very remarkable persons, H. Kirke White and Robert Hall, than I have at my command—both of them, in their way, men of great genius.

"'I did not know Kirke White till a little while before his death. That is, I never met him and conversed with him during his first academic year. But whenever I met him in the streets, I was impressed by his look and bearing. He was a tall, thoughtful-looking young man, with fine features, and with a complexion that seemed to indicate a life of severe study. In his second year, a month or two before his death, I several times met him in society. His manners well matched his character. They were simple, earnest, winning, and unaffected. He had the look of a man of genius.

"'So far as regards his features, Chantrey's medallion gives, I think, a good general notion of them, so far as can be given by a profile likeness in low relief.[1]

"'Robert Hall had ceased to live in Cambridge before my freshman's year, and of his manners in society I have no right to speak, as I do not remember to have ever exchanged a sentence with him, though on public occasions I have once or twice met him. But he occasionally revisited Cambridge; and then he always preached at the Baptist Meeting House in St. Andrew's Street, and whenever I could secure a seat on such occasions, I always attended the meeting. He always began with a prayer (sometimes of considerable length), uttered with great earnestness and simplicity, but injured in effective power from an apparent asthmatical difficulty of articulation. There was the same constitutional, or organic, difficulty in the commencement of his sermon. But the breathing of his sentences became more easy as he advanced, and before long there was a moral grandeur in his delivery which triumphed over all organic defects or physical weakness. While he rolled out his beautiful and purely constructed sentences, one felt as if under the training of a higher nature. In occasional flights of imagination, in discussions of metaphysical subtlety, we were for a while amazed, and almost in fear for the preacher. And then he would come down, with an eagle's swoop, upon the matter he had in hand, and enforce it with a power of eloquence such as I never felt or witnessed in the speaking of any other man. Such is my feeling now. Many a long year has passed away since I last heard Robert Hall. I have listened with admiration to many orators in the two Houses of Parliament, and to many good and heart-moving preachers; but I never heard one who was, to my mind, on the same level with Robert Hall.

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[1] This medallion is now in the antechapel of St. John's College.

"'I am at a friend's house, and I have very small spare time on my hands; but I have stolen away from the party for a few minutes, that I might do my best in answering your letter, which has just reached me. Alas! I know too well that this letter is not worth your reading; but I have, at any rate, endeavoured to show my goodwill to a brother fellow.

"'I remain, very faithfully yours,

"'A. SEDGWICK.

"'P.S.—I hope to return to Cambridge on Monday next. Let me send you a Happy Christmas.'"[1]

The days in which his lot was cast rendered it necessary that he should defend the study of geology. It was assailed strenuously by many worthy religious people, who quite misapprehended its nature and tendency, and sometimes he himself was treated as though he had been the enemy of religion, especially of revelation. The meaning of the first chapter of Genesis was so understood as to be quite inconsistent with the remote period to which the first creation was carried back by geologists; and Sedgwick had to establish the immense antiquity of the universe. It was assumed by many that the globe is not more than six thousand years old, overlooking what is now generally perceived, that the details of the first chapter of Genesis belong to a period which might be long subsequent to the *beginning*, when God created the heavens and the earth.

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[1] *My Autograph Book*, by the Rev. H. C. G. Moule.

Of the evidence of the world's antiquity Sedgwick has given a very clear synopsis in notes he transmitted to Dr. Pye Smith, which are printed in the supplement to his Congregational Lecture on *Scripture and Geology*.

But against all theories of self-development in the physical constitution of nature, and against the doctrine of the transmutation of species, Sedgwick resolutely set his face. A book once very popular, entitled *Vestiges of Creation*, which ran along such lines, excited his displeasure, and even indignation, and to his pen has been attributed a critique on the work, in the *Edinburgh Review*, of the most damaging and destructive description.

In his preface to the fifth edition of *A Discourse on the Studies of the University*, he asks: "Have we any proof of *specific transmutations* in the living world? We have not, so far as I understand the question, so much as the shadow of any proof of them. The constancy of organic forms, like species producing like according to a fixed law of generation, is the obvious and certain fact. These laws are to the organic world what the laws of elective affinity are to chemical combinations. Varieties there are, the limits of species are not well known, the riches of nature are so great that in the almost boundless varieties of animal forms created on a common plan one species often comes close upon another. As an inevitable consequence, naturalists have made many blunders, and their vanity may sometimes have led them to give new specific names where the new names were not called for. But the mistakes of naturalists alter not the laws of nature. Art has been pushed to the utmost in modifying the natural forms of organic life, but not so much as one true specific change has ever been brought about, so as to raise the progeny of any known animal to a higher grade in the organic scale. These are the broad conclusions we arrive at from all the facts and analogies offered to our sense. In this instance it will not serve our purpose to entrench ourselves among the dark corners of the animal kingdom, where (as in the case of the *entozoa*), from the inevitable want of evidence, we may, by casting away analogy, affirm that generation is ambiguous, and that species are inconstant."

Such a statement from some men might carry little weight, but when proceeding from one who had for years and years studied the facts of natural science, and was familiarly acquainted with the whole series of organic remains, it possesses force and authority which it were idle, not only for tyros, but even for adepts, to gainsay and resist. It is remarkable and amusing how many mere *readers* of science denounce submission to authority, when upon mere authority they are dependent for all they know, never having carried on any original researches themselves. Apart from the authority of others they are profoundly ignorant, and in opposition to Sedgwick, all such persons can do is to cite counter authorities; but it is difficult to find any one as well read in the records of creation, who can be set up as a second and equally learned judge upon this critical question.

It scarcely needs to be said that Sedgwick could

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[1] P. xxvi.

not for a moment tolerate any atheistic or pantheistic theory of nature. In opposing such idols of the imagination he was a perfect iconoclast, and his reading of nature's testimony to her Creator Lord and King was clear and distinct.

"In our contemplation of nature we behold a world not governed by *one* but by *many laws*, and each law so adapted to all the rest as to end in harmony and order. All this implies a unity of will in the great central and sustaining power of the universe, and we then ascend to a conception of one great intelligent Cause, ruling over all nature, dead, sensitive, moral, and intellectual. This belief to every son of man is the mother of his peace and joy, and it is no less the anchor and stay of every civilized community. Man is a religious being. Without religion he is in a state of savage darkness or moral mutilation, and whether the form of his religion be derived from a pure or a corrupted tradition, or spring from within himself, is immaterial to my present purpose: for I am not now asking what is the form of true religion; and however distorted it may be through ignorance and bad training, or the caprices of his fancy, or the pestilent vapours of moral taint, still the sentiment is there, and though his ill-guided strivings to grasp the counsels of his Creator be as powerless as the efforts of an infant in the nurse's arms while stretching out its hands to catch the moon, still the sentiment remains an inherent part of himself; nor will all the powers of sophistry and darkness ever root it out, so long as there is a principle of causality dwelling within his soul, leading him to the conception of general truth, binding the elements of his knowledge together, and thereby giving them strength and meaning, so long as he has any feeling of a law of conscience, so long as he has any perception of a law of moral government, so long as he has a conception of futurity, and a longing for future good."[1]

Again: "Those who exclude from their creed all conception of a personal and intelligent God of nature, must believe that dead, inanimate matter may, without external aid, and by its own inherent powers, work itself into what is vital, sensitive, and intellectual. They may maintain that what we call law is mere material order, and nothing else; that what we call adaptation is but a dream of fancy; that what we call intellect and mind is but a form of material manifestation; that conscience is but a material weakness; and that the hopes of future good are but an idle material dream; and in all this they are, at least, consistent. But if, on the other hand, we do see law and order and harmony in the world, whether animate or inanimate, and if we discern within it proofs of adaptation, wisdom, and goodness; then, whether we reflect on the world without, or trace the laws of thought and intelligent act by reflecting on our own internal consciousness, we do gain a firm grasp of what is meant by the sustaining as well as the creative power of God. One of these words (to repeat what has been said before) defines our conception of the orderly movements of the world, and of the second causes whereby they are upheld, and implies also, in conformity with our internal consciousness, a personal sustaining Power. The other word refers to the beginning of things, and (in like conformity with our nature, and without pretending to limit or define the first movements of creative power), refers to our conception of a great First Cause of all things, moral or material, organic or inorganic. To this belief we are constrained by what we see without us, and what we feel and know within ourselves. Nor can we cast away this belief, unless we strip off those inner elements of our nature, without which no sound system of philosophy ever has been, or ever can be, built up by man."[1]

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[1] Pref. to *Discourse*, p. cxliv.

Further: "If our planetary system was gradually evolved from a primeval condition of matter, we may well believe that every material change within it from first to last has been but a manifestation of the Godhead, and an emanation from His immediate will. Or we may suppose that new powers have by an act of creative interference been impressed on it at successive epochs of its changes; and that these new powers, working together with the old, *may* have brought about the next system of material conditions; or, if it be thought more in conformity with what we see of the modes of material action to suppose that the primeval system contained within itself the elements of every subsequent change, then is the primeval matter to the matured system of the world as the seed to the plant, or the egg to the living creature. Following for a moment the last of these hypotheses, shall this embryo of the material world contain within itself the germ of all the beauty and harmony, the stupendous movements and exquisite adaptation of our system—the entanglement of phenomena, held together by complicated laws, but mutually adjusted so as to work together to a common end; and the relation of all these things to the functions of beings possessing countless superadded powers bound up with life and volition? And shall we then satisfy ourselves by telling the laws of atomic action, of mechanical movements, and chemical combinations, and dare to think that in so doing we have made one step towards an explanation of the workmanship of the God of nature? So far from ridding ourselves by our hypothesis of the necessity of an intelligent First Cause, we give that necessity a new concentration by making every material power manifested since the creation of matter to have emanated from God's bosom by a single act of omnipotent prescience.[1]

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[1] Pref. to *Discourse*, p. clv.

Once more: "I have endeavoured," Sedgwick says, "from the light of nature to establish the following conclusions:—

"1. The being, power, and wisdom of God, as shown in the whole fabric of the material world, all the parts of which are bound together by material laws ending in harmony and order.

"2. A confirmation of this conclusion, drawn from the skill and prescience shown in the whole framework of animated nature.

"3. A further confirmation, drawn from the adaptation of all parts of nature, whether animate or inanimate, to one another. No parts are independent. Each part is governed by its own peculiar laws; yet subordinate to higher laws, by which the several parts are kept together under one common plan and purpose.

"4. The proof of a continued providential government, derived from the creative introduction, during many successive periods of time, of new organic structures adapted to new physical conditions of the earth.

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[1] *Discourse*, p. 28.

"5. The probability of a future state of being grounded on analogy. The organs of every animal are knit together with consummate skill, and wisely adapted to all external nature for the use and support of the beings endowed with them. In man, moral powers and capacities are superadded to his animal organs. He not only forms a conception of the future, but he has a 'longing after immortality.' To believe that such capacities and appetencies were given for no purpose—were to have no fruition in futurity—would be against all analogy, and imply a phenomenon that jarred with the universal harmony of nature. On grounds such as these many heathens 'have built their hopes of continued being and future glory.'"[1]

We make no apology for these lengthened extracts. They speak for themselves. They are words of wisdom from one who spent a lifetime in the study of nature; and therefore his testimony and the reasoning which rests upon it are peculiarly adapted to the present day, when atheistic and pantheistic theories are running riot to an extent beyond what Sedgwick ever witnessed. How energetically, were he still amongst us, would he lift up his voice against speculations which have nothing to recommend them save the names to which they are attached, the bold assumptions on which they rest at the very moment that their authors declaim against all other assumptions than their own, and the ingenuity and cleverness with which their sophistical arguments are drawn out.

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[1] *Discourse*, Appendix, p. 128.

Turning from natural to revealed religion, we find Sedgwick adducing a reply to Hume's famous objection to miracles. It is peculiarly characteristic of the author both in substance and style.

"Had Hume been told of the successive forms of animal life discovered by geologists, he ought, on his own principles, to have disbelieved the story, because it contradicts the supposed constancy in the laws of nature, and is therefore contrary to experience. But in this example (derived from geology), we are absolutely certain that his principles would have led him wrong. Let us next suppose him, by the evidence of his senses, or by any other kind of teaching, to have learnt the great palæontological facts discovered by geologists. What would then have been his conclusion? It is perhaps no easy matter to tell what would have been the conclusions of one who seemed to revel in doubt as if it were his natural element, and who went so far as to doubt his own existence; but, judging from his moral condition, and his apparent unwillingness or want of capacity to grasp the idea of a First Cause, he would probably have adopted, with the reserve of doubt, some theory of transmutation. But in doing this he would have utterly destroyed the foundation of his own argument against miracles: for the passage of a fish into a crocodile, of a whale into an elephant, or of a baboon into a man, is as perfectly contrary to vulgar experience (and therefore in Hume's sense as perfectly miraculous) as the act of making a deaf man hear, a blind man see, or giving back life to a body that is dead."[1]

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[1] *Discourse*, Preface, p. ccxxxi.

Serious charges were brought against Sedgwick's *Discourse on the Studies of the University.* It was said to contain many passages unfriendly, indeed decidedly antagonistic, to revealed religion. These accusations afford distressing instances of the length to which some people are carried by their prejudices and passions. Strange to say, they oppose natural religion with the view of supporting revealed religion, whilst revelation itself is ever appealing to proofs and illustrations of the Divine Being and perfections recorded on the pages of creation, and to moral and religious convictions which, until cruel sophistry tears them out, lie closely folded round the hearts of men. Sedgwick could well vindicate his advocacy of natural religion, but not to the detriment of that which is revealed. He knew and loved the gospel, and thus confessed it in unambiguous terms :

"The following are among the fundamental doctrines of our religion : that 'man is very far gone from original righteousness, and is of his own nature inclined to evil :' that our Maker is pure and holy, and requires from us nothing less than perfect obedience, perfect both in will and deed : that every son of man is therefore guilty before God, and under sentence of condemnation : that a remedy has been provided for us in the person of Jesus Christ ; who not only showed in Himself an example of perfect purity and holiness, but opened for us a way to future happiness by the voluntary sacrifice of Himself—thereby satisfying the severe attribute of God's justice, and blotting out the written sentence of our condemnation : that a faithful acceptance of this doctrine is the principle and foundation of our forgiveness, and by inherent moral necessity fills the heart with thankfulness and love: that a full perception of these doctrines is not enough: that after we are forgiven and restored to our Maker's favour, infirmity and corruption still cling to us: that we require, after admission to the covenant of mercy, through our whole lives continual support and renovation, to be maintained only by communion with God and the sustaining grace of His Holy Spirit: that in this way God may dwell in our hearts as our Maker, our Redeemer, and our Sanctifier: that from first to last this scheme of salvation is the free gift of God, not purchased by our own works, or claimed by us on any score of self-sustained inherent personal merit of our own. The proper effects of these great doctrines, when faithfully received in the heart, are an enlarged charity, a purity of life grounded on the highest sanctions, and a ready acknowledgment of the goodness and providence of God in all His dealings with us. The film which dims our vision falls away; the passions which desolate the world become obedient to law and order; we see in everything around us the power and benevolence of our Maker; all the higher faculties, moral and intellectual, receive their noblest exaltation, and now at length subservient to the true purposes of our being, become 'a rich storehouse for the glory of the Creator and the relief of man's estate.'"[1]

Sedgwick lived to a good old age, spending his days sometimes at Cambridge, sometimes at Norwich. Pleasant memories of his native dale followed him to the last, and mingled with the expression of his Christian faith and hope. "If a long life has been given me, am I to murmur because the infirmities of old age are beginning to press hard upon me? God forbid that such should be my bearing while under my Maker's hand. Nay, rather let me laud His holy Name for the countless and ill-deserved blessings He has showered upon me; and humbly ask Him, for Jesus' sake, His anointed Son, to pour into my heart the grace of thankfulness, and to cheer the remnant of my fast waning life with hopes becoming my grey hairs and my Christian profession. While asking my God and Saviour to help me in calling up such thoughts as these, I wish also to impress them upon my dear old friends in Dent and in the neighbouring dales, and not upon the aged only, but upon all my brother dalesmen of whatever age, especially now that I am winding up my final conclusion, pronouncing my farewell, and asking God to bless my dear birth-dale and those who dwell within it."[1]

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[1] *Discourse*, Appendix, p. 134.

"He delighted to tell how the simple peasant of his native dale who had known him in boyhood would, when he revisited it after a long lapse of years, still address him as of old, by his Christian name 'Adam,' for this mode of address was dear to him as speaking of a common brotherhood."[2]

To the last this admirable person retained those social qualities which endeared him to a large circle of friends who delighted to speak of "his unrivalled conversational powers and his noble and truth-loving spirit."

"His fascinating society," says one of his friends,

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[1] *Sedgwick Memorial*, Appendix, p. 67.

[2] Speech of Mr. Walpole at the Sedgwick Memorial Meeting.

"was everywhere desired, his sallies of genius and humour appreciated and repeated, his person loved and honoured; yet his religious fervour and moral simplicity never forsook him. To know him was not only to love and admire him, but to reverence his Divine Master whom he always acknowledged."

"My autograph-book," says a writer already quoted, (see p. 324) "contains a brief but invaluable record of his death-bed hours, from which I quote the following sentences:—

"'He slept most of the afternoon, but as the daylight faded, he awoke, and I heard him praying earnestly, but in so low a tone that I could not distinguish all he said, and was afraid of disturbing him by moving nearer. The following sentences I heard at intervals: "Washed in the blood of the Lamb." "Enable me to submit to Thy holy will." "Sanctify me by Thy Holy Spirit." The first and last sentences were repeated; then the sleep deepened. He never spoke again. About midnight the shadow of death came over his face, his breath became slower and very soft, and with a gentle sigh, at ten minutes past one in the morning, his spirit passed away.'"

Sedgwick died in 1873, and on the Sunday after his interment Dean Stanley preached a funeral sermon for him before the University.

"Who," said the preacher, "that ever saw the scorn of that fierce indignation against baseness or meanness or wrong, has not felt himself nerved to loftier aims? Who that ever read or heard his burning words of detestation and disgust against the miserable folly and sin of sensual self-indulgence, his admiration of whatever was unworldly, generous, and just, did not perceive how amidst the exuberance of his never-dying youth, amidst all the energy of political or theological or scientific strife, there was in that granite rock a crystal spring of affection, simple, tender, and true, as ever burst from the depths of human heart?

> 'His strength was as the strength of ten,
> Because his heart was pure.'

"He was, as far as in him lay, the salt, the Attic salt, the purifying salt, the invigorating salt, which kept us all from corruption, debasement, and decay. And not less was he the light of this our earthly scene. In his own peculiar field he fought the good fight of faith in this great doctrine, though many forsook it and fled. No fanatic partisan ever clung to ecclesiastical or political dogmas with more perfect submission or more ardent enthusiasm than he to the sublime Christian doctrine, that God is light, and in Him is no darkness at all, that God is truth, and the truth will in the end prevail. In this holy confidence, in this magnanimous hope, doubts and difficulties melted away. Under the magic touch of his reverential ardour the very stones seemed to cry out, the flinty rocks seemed to have found a voice, deep called unto deep; and 'the sons of God' seemed again to 'shout for joy' as he described the fastening of the foundations of the world and the laying the corner stones thereof."

"It was the whole man, the whole being in which this bright example burned and shone, that made the heart leap with joy as he drew near, and inspired the humblest and the dullest for the time with the inspiration of his own enthusiasm. Think of that eager, impetuous flow, that Homeric energy of eloquence, that caught up in its currents the incidents great and small of his vast and varied recollections; think of the flash of that eagle eye that was awakened to fire by whatever was great and good; the power of that faltering voice that was melted into tears by whatever was touching and tender." "Think of that childlike, simple, yet manly and understanding faith with which he dwelt at once with adoring reverence and fearless freedom on the central truths of the Christian faith, as though he had lighted upon them for the first time, with which he would read in public or in private the stirring passages of Holy Scripture. Think of the firm but faltering tones of overflowing thankfulness with which he would recount the many blessings which had followed him through his course of fourscore years. Think, let me add, of his calm and peaceful close, with the last words that trembled on his lips in the watches of the last night of his mortal life, 'Sanctify me by Thy Holy Spirit.'" [1]

After his death, his scientific and other friends at Cambridge, at a memorial meeting, vied with each other in extolling his achievements and his virtues, and the remarkable union, in his character and life, of science and religion was well described by Professor Selwyn and Mr. Walpole.

"We felt," says the former, "that in the hands of Professor Sedgwick geology was the handmaid of theology, and it was a great pleasure to pass literally and in fact from Genesis to geology—from our own lectures on the books of Moses to the Woodwardian's lecture room. We felt that the lecturer there was exhibiting facts and records that helped to fill up those pages which the sacred historian, intent on greater things, and having his commission in another sphere, had left vacant; showing how the power and wisdom of the great Creator had gradually prepared this earth for the dwelling of man. We were glad to hear him urging the same principle that we had been maintaining in the school of theology, that which is so well given in the great work of Basil, *The Six Days of Creation*, a work which deserves study even in these days of advanced science, viz. that we should not try to bring the speculations of philosophers on the things of heaven and earth into comparison with the simple and unstudied words of Holy Scripture.

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[1] *Purity and Light*, a Sermon by A. P. Stanley, D.D., pp. 27–29.

"With him, to use his own words, we were 'led into scenes of grandeur which taught us to feel in our hearts that we were among the works of the great Creator, the Father of all worlds, material or moral, and the ordainer of all laws,' as he pointed out to his class 'the wonderful manner in which the materials of the universe are knit together by laws which prove to the understanding and heart of man, that a great living intellectual and active power must be the creative head of the sublime and beautiful adjustments and harmonies of the universe.'"

"He was," added Mr. Walpole, "a mediator between theology and science. And this position he maintained because, though a geologist, he was very much more than a geologist, because while he resolutely vindicated a strictly scientific method of induction for the investigation of scientific truths, he recognised the existence of other truths also, resting on a different foundation; because all-important as he held it to trace the laws of physical phenomena, he felt that the heart and intellect of man could not rest satisfied with these alone; because, along with the spirit of scientific inquiry, he was endowed also with the spirit of hopefulness, of devout trust in an eternal purpose, that highest form of optimism which, however it might be decried by some, is yet the very breath of heaven to man. He not only found sermons, the most eloquent sermons, in stones, but he also found good in everything."

Butler & Tanner, The Selwood Printing Works, Frome, and London.